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# AUTOMATIC CONTROL IN THE GLASS PLANT

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**Some of the most interesting and important developments in all the history of glass making can be expected in the near future as modern methods of automatic control for the manufacturing processes become more widespread. This article discusses results already achieved and points out the more immediate possibilities for improved glass quality and more economical plant operation.**

Emerson said, "If a man build . . . a better mousetrap than his neighbor, though he build his house in the woods, the world will make a beaten path to his door." But in a more modern sense, this is not strictly true. If this lonely manufacturer wants to stay in business nowadays, he must build his better mousetraps by the carload and continue to do so. Furthermore, he must know exactly how and why he achieved the better one and be able to duplicate the original procedure under all conditions. In other words, some kind of production control is absolutely necessary at each step of a manufacturing process if uniformity in the finished article is to be secured.

From the time the first cave man fashioned his crude arrow heads, spears and stone knives, and continuing almost to the present era, this striving for uniform perfection in manufacture was in the hands of skilled craftsmen, men having the "know-how." Of necessity, complete reliance had to be placed in these trained eyes and hands, but the human factor was always present and not always infallible. So, to assist the craftsman, measuring stricks were developed; chemists found means for analyzing raw materials; physicists produced lenses for microscopic examination; mechanics and engineers provided micrometers for accurate sizing, precise scales for exact weighing, thermometers and pyrometers for temperature determination, gauges to indicate pressures, and so on. With the advent of such instruments, the "judgment" of the craftsman became less and less important and manufacturing operations began to approach the realm of exact science.

Even with these aids, however, the human equation in manufacturing technique still existed. Temperatures could rise or fall, depending upon the alertness of the operator; scale indications could be mistaken; pressure changes could go unnoticed. Furthermore, it was always difficult for the combination of operator and instrument to detect a trend to a change, so that the change itself would not be noticed until too late to make an adequate correction. So the next step toward satisfactory production control followed logically in the form of instruments to control certain operations automatically without human supervision. Almost all modern industries, from canned milk to automobiles, have come to depend on such automatic control instruments in certain stages of their processes and standards of quality and uniformity formerly unattainable are now an everyday matter.

In the utilization of automatic control the glass industry has been outdistanced by some others, this condition arising from the fact that glass production has only quite recently developed into a continuous, mechanized process. Only a few decades ago every glass plant was simply a workshop in which the art of the craftsman held full sway, but the demand for glassware in new forms and unheard-of quantities necessitated new and faster production methods. The problem of changing glass manufacture from an art to a scientifically controlled procedure has not been easy to solve, but great strides have been made. Some matters are still obscure and the trained eye and hand will be necessary for a long time to come, but it is rather unreasonable to assume that the utilization of modern control methods has reached its peak in the glass industry and that successful procedure in other industries will not in some way be adapted for use with glass.

Objections to automatic control arise for various reasons, such as cost, compared to "the wages of a few men," and lack of confidence in the apparatus caused by incomplete understanding of available devices and their operation. Some attempts at automatic control have failed miserably in glass plants, but in many cases the trouble has developed from improper selection and installation of equipment or from the fact that an important variable factor was overlooked and not tied into the control system. Instruments will not think. This function must still be performed by the human brain and every detail of the operation must be thought out in advance, completely and accurately, before turning it over to the instruments.

From the cost standpoint, it is well to consider the proper functions of automatic control apparatus carefully. Such apparatus is not primarily to save labor

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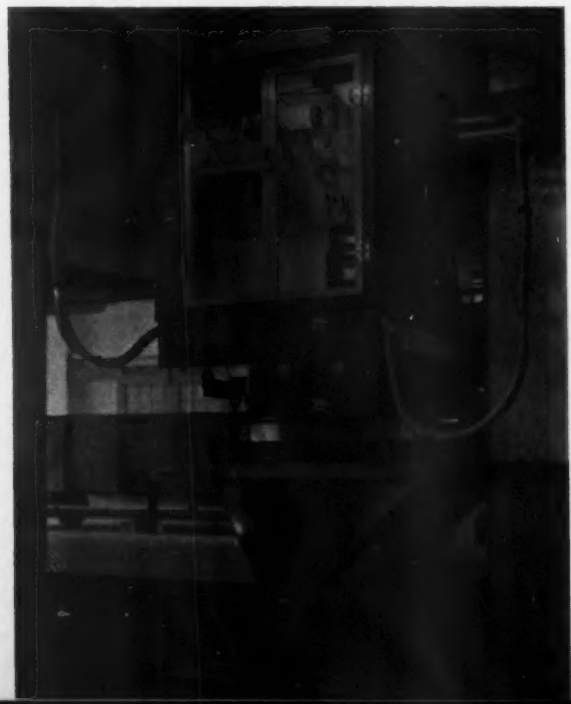
Photographs courtesy of Ford Motor Co., Leeds & Northrup, Askania Regulator Co., Bailey Meter Co., Surface Combustion Co., Libbey-Owens-Ford Glass Co.

Fig. 1. Above. An automatic weighing system for glass batch materials using pointer-type scales. Each hopper has electrically operating loading and discharge feeders which are automatically controlled by movement of the scale pointer. Collector belt runs continuously in housing on the floor.



and can seldom be justified on any such basis. Its real functions are to insure high quality and uniformity of the product and to stop losses that may be present unless it is used. By careful analysis the advisability of an automatic control installation can usually be established, but a good deal of common sense is necessary to see that the system does not get so complicated and costly that the point of diminishing returns is reached. Sufficient data is now at hand from successful installations to show what can be accomplished in a variety of glass plant operations and to point out possibilities for other applications that have not yet been generally adopted.

**Batch weighing**

Automatic control of batch weighing and proportioning operations is now being utilized to a considerable extent, but is, of course, best adapted for plants that produce only one or a few kinds of glass in comparatively large quantities. For the manufacture of a wide variety of glasses in smaller quantities, the necessary flexibility in automatic control can be secured only at unreasonable cost. When it can be used economically, however, automatic batch weighing has certain advantages which are reflected in higher quality and greater uniformity of the glass. Careful laboratory control of batch ingredients and proportioning is exercised in practically all modern plants and the ultimate aim of automatically controlled weighing is to provide a batch in commercial quantities which follows the laboratory specifications accurately and continuously.

The essentials of an automatic weighing system for batch include, for each ingredient, a hopper, power-operated loading and discharge feeders or gates, and an accurate scale that is fitted with control apparatus to operate feeders or gates and with suitable electrical and mechanical interlocks to insure proper sequence of operations. A proper system of interlocking is a most important part of every form of automatic control for industrial operations and the system may stand or fall on the ingenuity and dependability of the interlocking devices and their arrangement. This is particularly true in the case of automatic batch weighing.

Without going into a discussion of the details of an automatic batch weigher, it is apparent that several interlocks are necessary: (1) The hopper-loading feeder must not operate unless the discharge apparatus is shut off; (2) The discharge device must not function before loading ceases; (3) No hopper must discharge until all are filled with the proper weights of materials; (4) Discharge must not occur until the next section of the batch preparation system is ready to receive it.

The scale is, of course, the heart of the weighing system and both the pointer and beam types are being used. With certain types of feeders the scale can be arranged to cause rapid feeding until the desired weight is almost reached, then a slow dribble of material followed by complete stoppage at the exact weight. It is also possible to interlock the scale with the hopper discharge so that the hopper cannot be emptied if an excess weight is in it. This refinement introduces additional cost, how-

Fig. 2. Left. This automatic batch weighing system utilizes the beam type of scales. Scale, feeders, hopper and control are assembled in a complete unit for handling each ingredient. Here also, the collector belt runs in a housing on the floor.

ever, without a commensurate practical advantage and has generally been omitted from systems now in use.

Limits of accuracy in weighing should be carefully established for each batch ingredient. Modern scales and controls can be arranged to give almost any desired accuracy, but very close limits mean higher installation costs and the tolerance should be as wide as practical operation will permit. With the required accuracy determined properly, an automatic weighing system is free of most of the troubles that arise from manual control. It is well known that manual weighing is subject to sins of commission, as well as of omission, which the printing type of scale, quite generally used as a check, has been unable to eliminate entirely. Such difficulties as underweight, overweight and the omission of one or more ingredients, can be definitely overcome by means of automatic control. Proper maintenance of an automatic weighing system is a prerequisite for dependable operation. Labor saving, in comparision with a well-designed manual system, is almost negligible.

**Batch handling and mixing**

In automatic batching systems the handling of unmixed batch does not present much of a problem, since the weigh hoppers usually discharge upon a continuously running horizontal collector belt and an elevator is generally provided to lift the material to the proper level in the mixing house. It is customary to collect the entire batch in a surge bin or tank before it enters the mixer and this bin is important, because it provides interlocking controls for the weighing equipment which precedes it in the line. These controls include electrical indicators at full and empty levels, together with a power-operated discharge gate which is fitted with limit switches.

Surge bin interlocks may function as follows: (1) The weigh hoppers cannot discharge unless the bin gate is closed and the lower indicator shows empty: (2) The bin gate cannot be opened until the mixer has discharged its contents and is ready for the next load. In one installation the pre-mix surge bin has been mounted on scale levers that connect to a distant scale of the printer type. This apparatus records the total weight of the batch and serves as a check on the operation of the individual ingredient scales.

On the mixer itself the automatic control includes timing and interlocking action of the power-operated discharge device. Automatic timing of the mixing operation is accomplished by clock control of the discharge mechanism, the mixer running continuously and the time being set arbitrarily beforehand. The limit switches should be actuated directly by the discharge spoon or dipper itself to insure that it is withdrawn before the next batch enters the mixer.

**Mixed batch handling**

It is customary to discharge the mixer into a second bin, from which the batch is delivered to the transport-

**Fig. 3. Automatically controlled tramrail system for transporting batch from mixing house to tank in unit containers. Each train of containers is pulled by an electric tractor. The trolley wire is sectionalized, each section being energized through limit switches only when the section in front of it is clear. Full containers passing toward the tank, at the right; empty containers returning to the filling point at the left.**

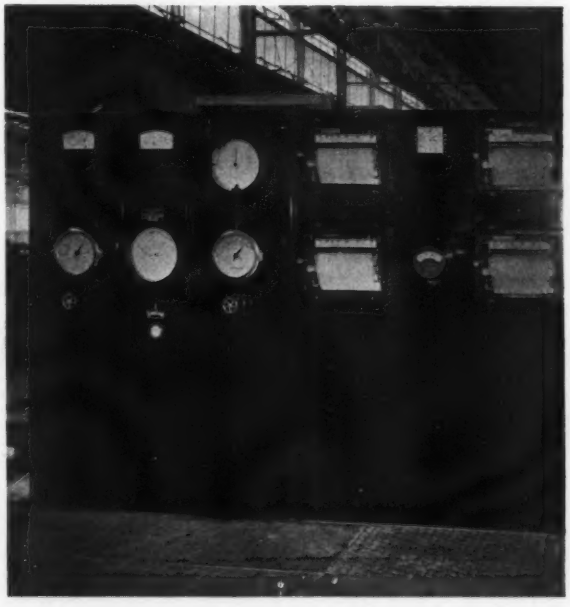


**Fig. 4. The end panel at the left carries instruments for the hydraulic (oil) type of furnace control. The fuel-air ratio is adjusted by the hand-wheel at the left and furnace pressure by the one at the right, the settings being shown by large dials above the handwheels. At the center is a gas flow meter and at the top are, left to right, a furnace pressure indicator, a furnace pressure recorder and a fuel-air indicator.**

ing equipment through a power-operated feeder and a magnetic belt. An electrical indicator at the bottom of the bin is interlocked with the mixer discharge dipper to prevent discharge of the mixer until the bin is empty. This indicator also stops the feeder and magnetic belt when the contents of the bin have all been delivered. The feeder and magnetic belt motors are started by a switch at the control board, when a batch can or other transporting device is in position, and this is the only manual control needed in a fully automatic system. All of the other functions of weighing and mixing follow in proper sequence automatically.

Transportation of mixed batch may be either continuous or intermittent, the former using an ordinary belt conveyor discharging into a bin near the furnace and the latter incorporating the use of unit containers in which the mixed batch is stored until fed into the furnace. No automatic control is needed, of course, in a belt installation or when unit containers are handled on buggies, electric trucks, or manually pushed along a tramrail. However, when unit containers are transported on a tramrail by power-operated devices, automatic or semi-automatic control is possible and has been utilized in several installations successfully.

Such an installation may be quite simple when serving a single tank at about the same level as the mixer discharge, since it is only necessary to divide the tramrail into blocks which are energized through limit switches by passing trains of batch containers. When the tank and the mixer are at different levels and several tanks are to be served, however, the system becomes more complicated and manually-controlled switching is usually necessary. As in other cases, automatic control of batch transport is not primarily a labor-saving device, its advantages being found rather in its ability to get the material to the tank quickly, with equipment and over a route not affected by other plant activities. Delays and misunderstanding which often accompany manual control of transport are, of course, eliminated, but as far as quality and uniformity of the glass are concerned, automatic control of unit container transport is probably not a factor.

**Fig. 5. A typical installation of instruments to control the fuel-air ratio on two glass tanks by means of two ratio recorder-controllers. At the top are gauges for uptake and furnace draft; in the center a recorder for gas pressure. Forced draft fan and piping for combustion air in the background.**

### Tank charging

In most continuous tank operations it is desirable that the level of the glass in the tank be held as near constant as possible. If the level gets too high, molten glass can spill over the tank blocks or edges of working receptacles; if constantly rising and falling, the glass becomes contaminated with block wash; if too low, the flow of glass to the working machine may be slowed up. A constant level tends to produce more stable conditions for the working machine and a more uniform product.

Because of the large amount of glass in the tank, as compared to the relatively small amount of batch fed at each time, maintenance of the glass level is at present left to the operator, who can, by careful attention to the furnace, do a good job of keeping it fairly constant. However, this is just another place where the worker must be the watch-dog and constantly on the alert to see that the level is held. Consequently, it would appear that here is a place for a trouble-free, fool-proof, automatic tank charger that would feed batch to the tank at a rate determined by the withdrawal rate, either in a stream or in piles, as desired, the rate of feed being controlled by a tendency or a trend of the glass level to rise or fall.

### Furnace combustion, temperature and pressure

Automatic controls for the melting operations, and subsequent annealing and heat treatment, have gained rather widespread use in the steel industry, but they have obtained only a foothold in the glass plant, as yet. However, as the manufacturers of control instruments become more familiar with the needs of the glass manufacturers and as the glass manufacturers, in turn, become better acquainted with the functions and possibilities of available control devices, it is quite probable that more and more glass-tank melting operations will be put under the control of mechanical watch-dogs.

Automatic control of the melting furnace has three main objectives: Maintenance of proper fuel-air ratio at all firing rates; uniform pressure in the tank atmosphere; holding of uniform temperature at a given point in the heating zone. These considerations leave out the matter of tank reversal which will be taken up separately. The reaching of these objectives is exceedingly difficult with even the best sort of manual control because in each case adjustments to secure required uniformity must be made on a trend toward a change rather than after the change occurs. In some automatic control applications there may be a question regarding necessity or economy, but in the matter of furnace control the advantages seem perfectly obvious in terms of glass quality, fuel consumption and furnace life.

The control of tank pressure through automatic ad-

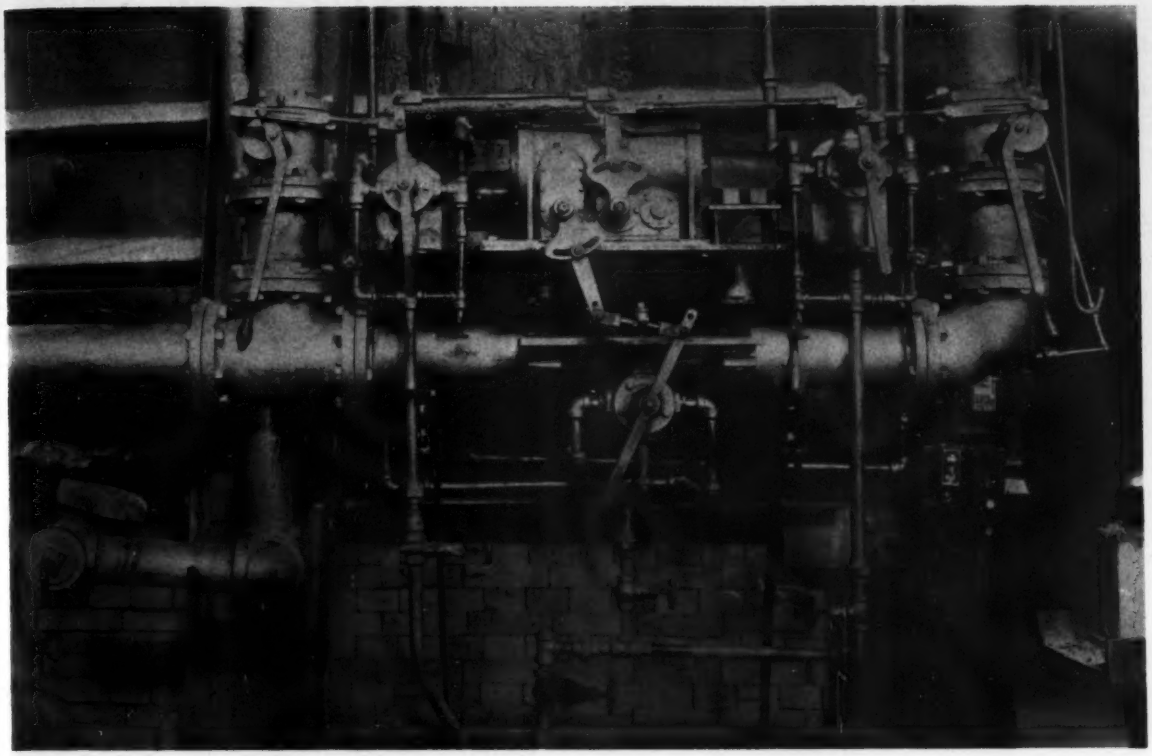


**Fig. 6. This valve-operating mechanism is actuated by an automatic reversal controller for an open-hearth furnace, working on the temperature-difference method. The various steps in the reversing operation are always made in the same number of seconds and in the same sequence.**

justment of the stack damper is now being quite generally used in modern tank installations. Its advantages have been accepted and dependable apparatus: hydraulic (oil), pneumatic and electrical, is available. Such controls have eliminated the draft variable from the furnace operation problem and have improved tank performance immensely, even with manual control of the other variables. But, since the other variables are known and the advantage of uniformity is so apparent, the combination of the automatic draft control with similar control for the entire field of tank operation deserves careful study.

Of itself, automatic temperature control in the heating zone is not a serious problem, since it is only necessary to increase the fuel supply to get a higher temperature or to cut down the fuel when things get too hot. The necessary apparatus includes the usual thermocouples, instruments and power-operated fuel valves, all of which are comparatively simple, dependable in operation and reasonable in cost. But the difficulty in such temperature control comes from the fact that a change in the fuel rate necessitates a proportional change in the combustion air rate and it is not possible to keep up with automatic regulation of fuel by any manual regulation of the air. In other words, automatic temperature control and automatic regulation of the fuel-air ratio are practically inseparable and it is quite apparent that lack of development of the latter in the glass industry has contributed largely to the small utilization of the former.

Automatic combustion control, i.e., automatic maintenance of a constant fuel-air ratio, is important not only because it permits more uniform temperature regulation, but also because it offers great possibilities for actual savings in fuel and in furnace maintenance, together with an actual increase in the amount of good glass melted. Necessary arrangements for automatic control of the fuel-air ratio include accurate measurement of the amounts of fuel and air flowing to the furnace, by some sort of recorder-controller, and apparatus to control the flow of fuel and air automatically, from the instruments. Several standard types of instruments and controlling mechanism are available and have been perfected through long usage in the control of regenerative furnaces. Measurements of natural gas, oil and air are made with orifices in the lines, but producer gas measurements are generally secured by measurement of steam flow to the producers. For satisfactory control and measurement, the combustion air must be furnished by a power-operated fan, since it is difficult to measure or control the air supply to a natural draft tank.

### Automatic furnace reversal

In the glass industry the use of an arbitrary time cycle for reversing regenerative furnaces is almost universal and, in all but a few installations, the reversal is manually controlled. In one large new plant the producer-fired furnace is reversed automatically on a time cycle by means of a clock-operated program controller and power-operated control valves. This apparatus has functioned well with a considerable improvement in uniformity of operation and a distinct saving in the amount of time necessary to reverse the furnace. Such a time sav-

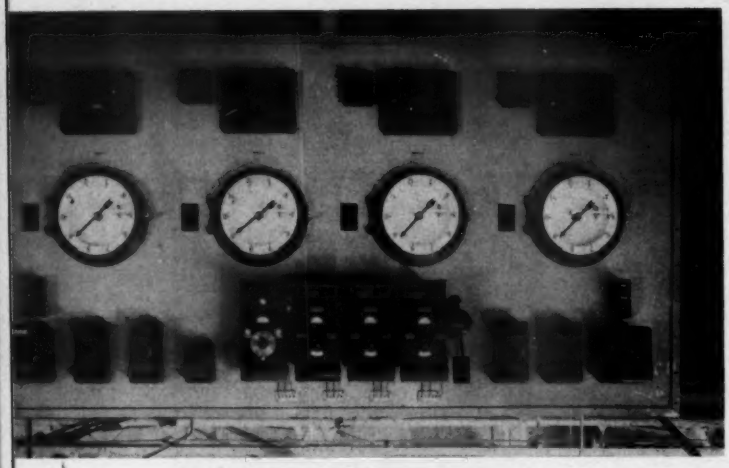


**Fig. 7. Located in a gallery above the four lehrs whose temperature it controls automatically, the indicating instruments of this panel are clearly visible from the floor below. The four automatic controllers are located in the center at the top of the panel.**

ing becomes important in the total furnace production, over a period of time, and tends to maintain improved heat uniformity.

But it is apparent that time cycle control does not, in itself, take into consideration the matter of temperature of incoming and outgoing gases, the proper heat balance between the checker chambers on the two sides of the tank, and whether the checker chambers are ready for the reversal at the expiration of the arbitrary time cycle. The balance must be watched by the operater and adjustments must be made to compensate for differences, bringing in the human equation again. Control instruments for reversing on temperature measurements are now available and the matter is being carefully considered by the glass manufacturers.

In general it may be said that two methods of temperature control are available. First, reversal may occur when the temperature of either the outgoing or incoming gas reaches a predetermined maximum or minimum figure, respectively. Second, the furnace may be reversed when the temperature difference between the incoming and outgoing gases reaches a predetermined amount. The first method is usually based on a maximum temperature in the hot-side regenerator, whereby overheating of the checkers is prevented, but from the standpoint of over-all efficiency the method still neglects the important factor of incoming air temperature and its effect on combustion.

Temperature-difference control of reversal, on the other hand, seems to include all of the necessary variables and to offer a practical method for reversing the glass tank furnace automatically. Its use is widespread on regenerative furnaces in the steel industry, in which certain definite advantages over manual control have been shown by actual operation data: (1) Greater amount of heat is restored at a higher preheat, resulting in smaller fuel requirement, less excess air and lower stack losses. (2) Controlled preheat cycle improves combustion rate, flame temperature and completeness of combustion. (3) Furnace reverses quicker, thereby reducing temperature drop during reversal and increasing actual melting time. (4) Correct heat balance is maintained continuously on both sides of the furnace, even after normal checker deterioration. (5) Slower deterioration of checker and furnace refractories and protection against burn-outs.

The mechanism for automatic reversal of a regenerative furnace on a temperature-difference basis is actuated, of course, by thermocouples and these couples are usually located in the air flues near the bottom of the checkers. A special type of recorder-controller measures the temperatures on both couples at short intervals and, when the temperature difference has reached the predetermined amount, commands the operation of the mechanism which actuates the air and gas valves to reverse the furnace. All valve movements for reversal are performed in proper sequence, the fuel being shut off before the air valves reverse.

### Annealing temperature control

In the annealing process there are two important variables: (1) the temperature in the heating zone, and (2) the cooling gradient. Of these two the annealing temperature is susceptible to automatic control, and most modern lehrs are equipped with such apparatus. The advantage is the maintenance of a more uniform temperature than can possibly be achieved with manual control. Equipment of the same type used on lehrs can be adapted also for temperature control in feeder forehearths, decorating lehrs and drying ovens.

Apparatus for automatic temperature control includes thermocouples at proper points and recorder-controllers that actuate some form of power-operated fuel valves. Recorders of the indicating type are a good feature, since conditions at the critical zone can be observed at any time by the operator. One of the accompanying illustrations shows an instrument board for the automatic temperature control of a battery of four lehrs, the apparatus including indicating recorders, controllers and switches.

### Miscellaneous controls

The foregoing applications of automatic control have to do with the actual processing of the glass until it reaches its final form, but there are many more places in which the judicious utilization of automatic control can be effective for greater efficiency, speedier operation and improved safety. The possible applications are so varied that space does not permit detailed consideration. Among the more important, however, may be mentioned automatic control of special materials-handling machinery, particularly of the intermittent type; automatic changeover of key drives from regular to auxiliary power in case of regular power failure; and automatic power shut-off in case of jamming or accidental breakage. Independent power plants also offer many opportunities for automatic control of boilers, prime movers and generating equipment.

Although the foregoing observations indicate a wide variety of possible applications in the glass plant, it should be apparent that no plant operator is going to solve all of his production problems simply by rushing pell-mell into automatic control installations at every susceptible point. Under proper conditions of produc-

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# A. C. S. PREPARES FOR CHICAGO MEETING

**Forty-first annual meeting of the American Ceramic Society will be held in the Stevens Hotel, Chicago, April 16th to 21st. Plans for a program of widespread interest near completion and a record attendance is expected.**

The selection of Chicago for the Forty-first Annual Meeting of the American Ceramic Society seems to meet with general approval among the members, as evidenced by the expressed intention of a greater than usual number to check in at the Stevens Hotel headquarters next month. Furthermore, advance information from the committees in charge of the affair indicates that those who attend will not be disappointed, either in the scope and variety of the technical program or in the arrangements made for their entertainment during the lulls between the working periods of the session. Activities will commence on Sunday, April 16th, and will continue until the following Friday.

The program of papers to be presented at the Chicago meeting is not complete as this issue of THE GLASS INDUSTRY goes to press, but the tentative list arranged by the various division program committees and released by Secretary Purdy carries a large proportion of titles that will be of interest and value to members of the Glass Division and other glass men. As a matter of fact nearly a third of the papers fall into this category and perusal of the following selected list will give an idea of what will be in store for the glass technicians and operators at Chicago:

**Observations on the Slagging of Glass Furnace Checkers.** *By W. L. Fabianic, Owens-Illinois Glass Co., Alton, Ill.*

**Spalling of Silica Brick During Heating and Cooling of Furnaces.** *By J. M. McKinley, North American Refractories Co., Cleveland, Ohio, and S. M. Phelps, Mellon Institute, Pittsburgh, Pa.*

**Recent Developments in Batch-Mixing of Glass Formulas.** *By J. P. Martin, Lancaster Iron Works, Lancaster, Pa.*

**Firing Decorations on Glass Ware.** *By C. E. Robertson, Du Pont Co., Perth Amboy, N. J.*

**Window Glass Plant for China.** *By Sun Kuan Han, J. Earl Frazier and Alexander Silverman.*

**Symposium on Analytical Procedures: Methods of Analysis of Silicates and Silicate Products.** *By Committee on Analytical Procedures: E. W. Koenig, Chairman; W. R. Lester, Glass Division; M. Boszin, Refractories Division; L. J. Trostel; G. H. Chambers, Materials and Equipment Division.*

**Notes on Chemical Analysis of Glass.** *By M. B. Vilensky, Owens-Corning Fiberglas Corp., Newark, Ohio.*

**Certain Phases of Glass Analysis.** *By A. K. Lyle and P. A. Webster, Hartford-Empire Co., Hartford, Conn.*

**Color Changes of Glasses When Exposed to Daylight.** *By W. Weyl, Penn State College, State College, Pa.*

**Activity of A.S.T.M. Committee on "Durability Methods."** *By G. E. F. Lundell, National Bureau of Standards, Washington, D. C.*

**Durability of Glass.** *By A. K. Lyle, Hartford-Empire Co., Hartford, Conn., and W. R. Lester, Maryland Glass Co., Baltimore, Md.*

**Some Notes on Effect of Solubility of Glass on Behavior of the Glass Electrode.** *By D. Hubbard, E. H. Hamilton and A. N. Finn, National Bureau of Standards, Washington, D. C.*

**X-Ray Study of Boric Oxide-Silica Glass.** *By B. E. Warren, Massachusetts Inst. of Technology, Cambridge, Mass.*

**Silicate-Water Systems.** *By G. W. Morey, Geophysical Laboratory, Washington, D. C.*

**Effect of Alumina on Devitrification of Soda-Lime-Silica Glasses.** *By W. B. Silverman.*

**Surface-Tension Measurements of Glass by a Modified Dipping Cylinder Method.** *By C. L. Babcock.*

**Hardness of Glass.** *By C. G. Peters.*

**Elastic and Viscous Properties of Potash-Silica Glasses in Annealing Range of Temperature.** *By N. W. Taylor and Robert Doran, Penn State College, State College, Pa.*

**High-Speed Photography of Glass During Fracture.** *By H. E. Edgerton, Massachusetts Inst. of Technology, Cambridge, Mass.*

**Frederick Carder, Dean of American Glassmakers.** *By Alexander Silverman, University of Pittsburgh, Pittsburgh, Pa.*

**A Critical Examination of the Load Test for Refractories.** *By F. H. Norton, Massachusetts Inst. of Technology, Cambridge, Mass.*

For the convenience of its readers who will attend the meeting, THE GLASS INDUSTRY will publish in its next issue a final selected list of the titles and abstracts which will be of primary interest to glass men. Papers for presentation at the meeting are still being received and it is expected that others of great importance will be added to the above list. Secretary Purdy is urging early submission of papers by all members.

### The Orton Lecture

As in past years, the opening event of the annual meeting will be the Orton Memorial Lecture, which is scheduled for Sunday evening at seven o'clock in the Grand Ballroom of the Stevens Hotel. The American Ceramic Society has honored itself by selecting as the 1939 lecturer Mr. Lawrence E. Barringer, long associated with the General Electric Co. as ceramic specialist and engineer of insulations. Mr. Barringer needs no introduction to the members, since he himself has been a member of the society since 1905 and closely allied with its activities. He was president of the society in 1916 and has since served the organization in various capacities, including chairmanship of the publications and rules committees, dean of fellows, chairman and trustee of the Art Division. (*over*)

### American Institute of Ceramic Engineers

The formal organization of the American Institute of Ceramic Engineers will be completed at a meeting scheduled for Wednesday, April 19th. Officers of the Institute for 1939 will be elected, the following names have been submitted by the Nominations Committee: For President, J. L. Carruthers, Ohio State University, Columbus, Ohio; for Vice-President, H. N. Baumann, Jr., Carborundum Co., Niagara Falls, N. Y., H. G. Wolfram, Porcelain Enameling Mfg. Co., Baltimore, Md.; for Secretary, C. M. Dodd, Missouri School of Mines & Metallurgy, Rolla, Mo., S. J. McDowell, General Ceramic Co., Keasby, N. J.

Among the more important subjects up for discussion at the meeting will be the membership rules and qualifications for membership. Other matters of interest and importance to ceramic engineers in attendance at the Chicago meeting will be discussed and it is expected that a full attendance of Institute members will be present at the Wednesday meeting.

### Entertainment and so forth

Evidence of much scurrying around by the local committees is found in the list of entertainments, tours, etc., already planned. Music, of both the vocal and instrumental variety, will provide a suitable background for the get-acquainted-all-over-again business of Sunday. Monday evening . . . openhouse . . . sandwiches . . . beer . . . German band . . . singing (amateur and professional) . . . entertainment (also amateur and professional) . . . we'll be seeing you. Usual dinner dance Tuesday—seven to nine, special orchestra and singing and playing strollers—then dance till one—good 10-piece orchestra—whole thing will cost you two-fifty, tax and all.

Dinners for students and alumni of the various colleges represented are set for Monday evening also, seven to nine, followed by the Students Reception in the Boulevard Room of the Stevens. Wednesday will be an open night, but the committee will take you to see the color-press departments of the Chicago *Tribune*, if you want to go, and 250 of you can visit the studios of WGN afterward. For the feminine contingent at the Chicago meeting Wednesday has been selected for a tour of Marshall Field's, followed by a bridge luncheon at the store, talk and demonstration on table settings, and a style show, maybe.

### Annual Meeting Sessions

All sessions of the annual meeting will convene at nine o'clock each morning and end at five. The general session is scheduled for all day Monday, April 17th, and will convene in the North Ballroom. Division sessions will take place on Tuesday and Wednesday, the Glass Division meeting occupying the North Ballroom also.

Educational exhibits will occupyy space in the east-side, third-floor corridor, and industrial and commercial exhibits will be staged in private rooms on the fifth floor. Registration booth will be found at the south end of the third floor corridor; Room 412 will be headquarters for the local committee; Room 451 will be the student lounge.

Many ceramic manufacturing plants are located in the city of Chicago and visitors to the annual meeting will be given an opportunity to visit them. Chicago glass plants are the Inland Glass Works at 6101 West 65th St., and the Johnson Glass Co., located at 5248 N. Elston Ave. Other interesting plants include the Edison General Electric Appliance Co., one of the largest producers of electric ranges in the Country, and the big plant of the Western Electric Company.

## AUTOMATIC CONTROL IN THE GLASS PLANT

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tion volume, product variety, plant equipment, fuel, etc., automatic control is a very useful and efficient tool that can be used to secure a product of higher quality and greater uniformity. Sometimes it also offers an opportunity for very attractive reductions in operating costs. But every application is a special problem in itself and thorough study is needed to determine the actual economy, as well as the technical requirements of the installation.

On the other hand, consideration of automatic control should not be prejudiced by preconceived notions or empirical methods, no matter how time-honored. It is a practical engineering problem and can be solved by practical engineering methods. Furthermore, all factors of glass plant production cost should be taken into consideration and too much emphasis should not be placed on the obvious factors of fuel and labor costs. One month longer productive life of a tank, a decrease in checker maintenance, or the elimination of a run of bad glass through accurate batching, are just as tangible in the final cost accounting as the wages of a man or the price of a thousand feet of gas.

And finally, the psychological factors that have a bearing on an automatic control installation should not be forgotten. The apparatus should not be left to the tender mercies of an uninformed or unsympathetic personnel. It has already been remarked that instruments will not think for themselves; neither will they fight their own way. The reasons for the installation and the expected results should be clearly explained to the operating organization, so that the men will be familiar with the new tool and able to recognize it as a development that will help them in their everyday jobs. Fitting automatic control into the glass plant organization is not the least important part of its application.

## PRODUCTION FIGURES FOR THE GLASS INDUSTRY DURING JANUARY

**Window Glass:** During January, 1939, the production of window glass was 943,184 boxes which represented 58.1 per cent of industry capacity. As compared with this, January, 1938, production was 705,721 boxes which represented 43.5 per cent of industry capacity.

**Plate Glass:** The production of polished plate glass by member companies of the Plate Glass Manufacturers of America during January, 1939, was 12,209,080 sq. ft. as compared to 12,691,262 sq. ft. produced in the preceding month, December, 1938, and 5,119,182 sq. ft. produced in the corresponding month, last year, January, 1938.

**Glass Containers:** Production of glass containers during the month of January, 1939, was 3,589,204 gross and shipments were 3,473,133 gross.

# AN ATTEMPT TO CORRELATE SOME TENSILE STRENGTH MEASUREMENTS ON GLASS: III

By JAMES BAILEY
Hartford Empire Co.

*This is the third instalment of Mr. Bailey's paper, which began in* THE GLASS INDUSTRY *for January. One chapter follows, concluding the discussion in the April number.—The Editor.*

## CHAPTER III: THE STRENGTH-TIME RELATION

In order to study the variation of strength with time, it is a matter of great importance that the size of the specimen be kept constant throughout any one series of tests, otherwise the change of area will be very likely to affect the result in an unknown manner. Moreover it is the custom to test glassware under a constant rate of *loading* instead of a constant rate of *stressing* and when this is done the specimens must have very nearly the same dimensions or the measured relation of strength to time may be seriously affected. Data suitable for working out the *Strength-Time* relation are relatively few. Of these the work of Black[19] and Preston[20] will be selected. Black's figures were obtained on specimens of plate glass of the thickness shown. They were 2" wide and 10" long and were tested across supports 8" apart. One diamond cut was up and one was down.* The load was applied by one central knife edge and was increased at a definite rate until the specimen broke. His results are given in Table IX.

*Private communication.
[19]Loc. Cit.
[20]F. W. Preston, "The Time Factor in the Testing of Glassware," Jo. Am. Cer. Soc., Vol. 18, No. 7, p. 220, July, 1935.

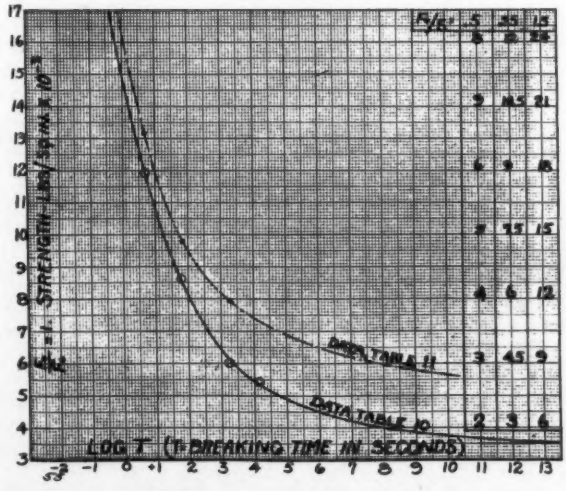


**Fig. 13. Extrapolated curves of Preston's data giving the relation between Strength and Breaking Time under constant stress.**

TABLE IX. STRENGTH VS. RATE OF STRESSING BLACK[19]

| Test | Inch Thickness | Time (Seconds) | □ Modulus of Rupture | γ Rate of Stressing |
|---|---|---|---|---|
| 1 | .117 | 7.0 | 10765 | 92,300 |
| 2 | .115 | 17.7 | 9042 | 30,600 |
| 3 | .117 | 45.0 | 7701 | 10,300 |
| 4 | .117 | 120.0 | 7044 | 3,520 |
| 5 | .117 | 360.0 | 6913 | 1,152 |
| 6 | .114 | 960.0 | 6494 | 406 |

□ Lbs./sq. in.
γ Lbs./sq. in./min. (Author's computation.)

Preston's[20] data are given in the two following tables. Table X was obtained on specimens of plate glass ¼" thick, 2" wide and 16" between supports. Both diamond cuts were on the compression side. The load was applied by one central knife edge and remained constant throughout the experiment. The time given is the time from application of the load until the specimen broke.

TABLE X. STRENGTH VS. TIME UNDER CONSTANT STRESS (PRESTON)
¼" Plate Glass 2" x 16"

| Time Seconds | Modulus of Rupture Lbs./sq. in. |
|---|---|
| 5 | 11,900 |
| 60 | 8,600 |
| 1800 | 6,000 |
| 14400 | 5,420 |

The data in Table XI were collected on a fine grade of Fourcault drawn window glass cut into specimens 0.125" thick and 2" wide, tested across supports 4" apart. Both diamond marks were on the compression side. The load was applied by one central knife-edge.

TABLE XI. STRENGTH VS. TIME UNDER CONSTANT STRESS (PRESTON)
⅛" Fourcault Glass 2" x 4"

| Time in Seconds | Modulus of Rupture Lbs./sq. in. |
|---|---|
| 5 | 13,150 |
| 60 | 9,700 |
| 1800 | 7,950 |

It is evident that these three tables cannot be compared directly, for Black's load started from zero (or a relatively small stress) and gradually increased until the specimen broke. Hence, the first part of the time was spent at stresses so low that they could not have contributed materially to the final breakage. On the other hand, all of the time in Preston's experiments was spent at the maximum stress. Both of these systems of testing have merit, but Black's has many advantages as a test procedure because no matter what the rate of application of the load, the specimen must eventually break and some measure of the time will result, whereas Preston's system breaks down completely at low levels of stress; for

example, strong samples would sustain the load indefinitely while the weaker ones would fail in perhaps a relatively short time. An average of such values has no physical significance, and hence the accuracy of the low-strength long-time values may be somewhat in doubt.

This behavior is clarified if Preston's data are plotted as in Fig. 13. Bearing in mind that strength measurements on glass normally show a variation of ±20 per cent of the mean, it can be seen that at a strength level of 5,000 lbs. per square inch, the strong samples would have a breaking time of the order of $10^8$ sec., the weaker ones would have a breaking time of the order of $10^{3.3}$ sec., while the average would be approximately $10^{4.7}$ sec. A numerical average of these would be controlled almost entirely by the stronger samples. Some logarithmic method of averaging should be used in such cases. However, it is fortunate for the purpose at hand that the lower end of each curve, Fig. 13 is not of very great importance.

Just what constitutes the mechanism of delayed breakage in glass and other substances is not definitely known. It seems reasonable to suppose that the underlying principles are similar in all substances since the decrease of strength with time is almost a universal phenomenon, although, of course, its degree varies with the material.

In metals this phenomenon is associated with "fatigue" or "creep" and because of its importance and the greater amenability of metals to such study, a number of useful facts have been developed.

If a specimen of steel is subjected to alternating cycles of stress, a threshold of stress is found below which the metal will withstand the stresses forever. Above this threshold, the metal will eventually fail. Failure starts as a small crack which gradually increases in size and finally results in rupture of the test piece. The growth of such cracks in terms of cycles of stress at a definite level of applied stress has been studied by R. E. Peterson at the Westinghouse Research Laboratories and by A. V. deForest.[21] A theory of the development and growth of fatigue cracks is given in an article by B. F. Langer[22], from which the following is condensed. Peterson placed his specimen in the testing machine and subjected it to alternating stresses of the desired magnitude. From time to time the test piece was removed from the machine and heated to produce coloring. After final breakage, the progress of the fracture could be determined from the coloration of the crack.

[21]A. V. de Forest, "The Growth of Fatigue Cracks," Jo. of Applied Mech., Trans. A.S.M.E., Vol. 58, 1936, p. A-23.
[22]B. F. Langer, "Fatigue Failure from Stress Cycles of Varying Amplitude."

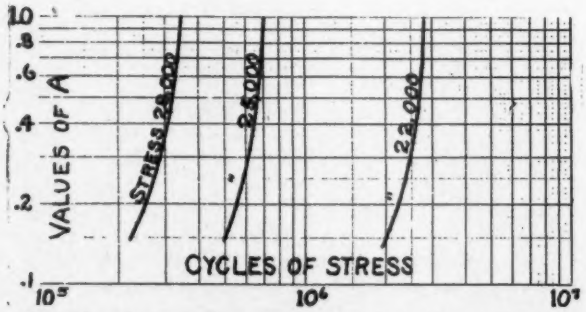


**Fig. 14. Peterson's tests: Development of a crack in a metal test piece as a function of cycles of stress.**

**TABLE XII. SUMMATION OF STRESS-BREAKING EFFECT PER UNIT TIME FROM LOWER CURVE FIG. 13—SUMMED FOR RATE OF 100 LBS. PER SQ. IN. PER SEC.**

| *Stress, lb. p. s. i.* | *Log T* | $\frac{1}{T}$ | *Sum* |
|---|---|---|---|
| 3500 | 13 | | |
| 600 | 12 | | |
| 700 | | | |
| 800 | | | |
| 900 | | | |
| 4000 | 7.95 | .00000001123 | |
| 100 | 7.42 | .00000003802 | .000000049 |
| 200 | 7.00 | .00000010 | .000000149 |
| 300 | 6.55 | .0000002819 | .000000431 |
| 400 | 6.23 | .0000005889 | .000001020 |
| 500 | 5.95 | .000001123 | .000002143 |
| 600 | 5.65 | .000002239 | .000004382 |
| 700 | 5.40 | .000003982 | .000008364 |
| 800 | 5.15 | .00000708 | .000015444 |
| 900 | 4.95 | .00001123 | .00002667 |
| 5000 | 4.72 | .00001906 | .00004573 |
| 100 | 4.56 | .00002755 | .00007328 |
| 200 | 4.38 | .00004169 | .00011497 |
| 300 | 4.22 | .00006026 | .00017523 |
| 400 | 4.08 | .00008318 | .0002541 |
| 500 | 3.92 | .0001203 | .0003787 |
| 5600 | 3.78 | .0001660 | .0005447 |
| 700 | 3.66 | .0002188 | .0007635 |
| 800 | 3.54 | .0002885 | .001052 |
| 900 | 3.42 | .0003802 | .001432 |
| 6000 | 3.32 | .000478 | .001910 |
| 100 | 3.24 | .0005755 | .0024857 |
| 200 | 3.15 | .0007080 | .0031937 |
| 300 | 3.07 | .0008512 | .0040447 |
| 400 | 3.00 | .00100 | .0050447 |
| 500 | 2.91 | .001231 | .0062757 |
| 600 | 2.85 | .001413 | .0076887 |
| 700 | 2.78 | .001660 | .0093487 |
| 800 | 2.71 | .001950 | .0112987 |
| 900 | 2.64 | .002291 | .0135897 |
| 7000 | 2.58 | .002631 | .01622 |
| 100 | 2.52 | .00302 | .01924 |
| 200 | 2.46 | .003468 | .02271 |
| 300 | 2.41 | .003891 | .02660 |
| 400 | 2.35 | .004467 | .03105 |
| 500 | 2.29 | .005129 | .03619 |
| 600 | 2.23 | .005889 | .04208 |
| 700 | 2.18 | .006607 | .04869 |
| 800 | 2.13 | .007414 | .05610 |
| 900 | 2.08 | .008318 | .06442 |
| 8000 | 2.03 | .009333 | .07375 |
| 100 | 1.99 | .01024 | .08400 |
| 200 | 1.94 | .01150 | .09549 |
| 300 | 1.89 | .01289 | .10838 |
| 400 | 1.85 | .01413 | .12251 |
| 500 | 1.81 | .01549 | .13800 |
| 600 | 1.77 | .01699 | .15500 |
| 700 | 1.72 | .01906 | .17406 |
| 800 | 1.68 | .02090 | .19496 |
| 900 | 1.64 | .02291 | .21787 |
| 9000 | 1.61 | .02455 | .24242 |
| 100 | 1.57 | .02692 | .2693 |
| 200 | 1.53 | .02952 | .2988 |
| 300 | 1.49 | .03236 | .3312 |
| 400 | 1.45 | .0355 | .3667 |
| 500 | 1.41 | .03891 | .4056 |
| 600 | 1.38 | .0417 | .4473 |
| 700 | 1.35 | .04467 | .4920 |
| 800 | 1.32 | .04787 | .5398 |
| 900 | 1.28 | .05249 | .5923 |
| 10000 | 1.25 | .05624 | .6486 |
| 100 | 1.22 | .06026 | .7088 |
| 200 | 1.19 | .06457 | .7734 |
| 300 | 1.16 | .06919 | .8426 |
| 400 | 1.13 | .07414 | .9167 |
| 10500 | 1.10 | .07944 | 9962 |
| 10600 | 1.07 | .08512 | 1.081 |
| 700 | 1.04 | .09121 | 1.172 |
| 800 | 1.01 | .09773 | 1.270 |
| 900 | 1.98 | .1048 | 1.375 |
| 11000 | 1.94 | .1149 | 1.490 |
| 100 | 1.91 | .1231 | 1.613 |
| 200 | 1.89 | .1289 | 1.741 |
| 300 | 1.86 | .1381 | 1.880 |
| 400 | 1.83 | .1480 | 2.028 |
| 500 | 1.80 | .1585 | 2.186 |
| 600 | 1.78 | .1660 | 2.352 |
| 700 | 1.75 | .1738 | 2.526 |
| 800 | 1.73 | .1863 | 2.7126 |
| 900 | 1.70 | .1996 | 2.912 |
| 12000 | 1.67 | .2138 | 3.126 |
| 100 | 1.64 | .2291 | 3.355 |
| 200 | 1.61 | .2455 | 3.600 |
| 300 | 1.59 | .2571 | 3.857 |
| 400 | 1.56 | .2755 | 4.133 |
| 500 | 1.53 | .2952 | 4.428 |
| 600 | 1.50 | .3163 | 4.744 |
| 700 | 1.47 | .3390 | 5.083 |
| 800 | 1.45 | .3549 | 5.438 |
| 12900 | 1.43 | .3716 | 5.810 |
| 13000 | 1.41 | .3891 | 6.200 |
| 100 | 1.39 | .4074 | 6.606 |
| 200 | 1.36 | .4366 | 7.043 |
| 300 | 1.33 | .4678 | 7.511 |
| 400 | 1.31 | .4898 | 8.000 |
| 500 | 1.29 | .5130 | 8.514 |
| 600 | 1.27 | .5371 | 9.051 |
| 700 | 1.25 | .5624 | 9.613 |
| 800 | 1.23 | .5890 | 10.20 |
| 900 | 1.21 | .6166 | 10.82 |
| 14000 | 0.19 | .6457 | 11.46 |
| 100 | 0.17 | .6761 | 12.14 |
| 200 | 0.15 | .708 | 12.85 |
| 300 | 0.13 | .7499 | 13.60 |
| 400 | 0.11 | .7763 | 14.37 |
| 500 | 0.09 | .813 | 15.19 |
| 600 | 0.07 | .8512 | 16.04 |
| 700 | 0.05 | .8913 | 16.93 |
| 800 | 0.03 | .9333 | 17.86 |
| 900 | 0.015 | .9661 | 18.83 |
| 15000 | 0.0 | 1.0 | 19.83 |

DeForest measured the length of the crack at the surface at various times. The results are given in graph form and it is shown that the curves are parallel within the experimental error, when the results are plotted as in Fig. 14, which gives Peterson's Tests. The ordinate A is the ratio of the area of the crack at the particular time to the area at final breakage.

If these curves are parallel, then it follows that the mechanism of the break is of the same character no matter what the stress level, and we may write

$$\frac{X_1}{C_1} = \text{the weakening effect}$$

where $X_1$ is the cycles run at a certain stress and $C_1$ is the total number of cycles required to break the sample at this stress. When the curves are parallel, the same value of A in Fig. 14 will be obtained for every stress provided only that the ratio $X_1/C_1$ has the same numerical value in each case. We could, for example, say that the weakening effect (as distinct from A) is the same for each cycle at a particular stress and that the product $\frac{1}{C_1}(X_1)$ is the part of the breakage due to $X_1$ cycles.

If the specimen were run at several different stresses for a certain number of cycles at each then when the sum

$$\frac{X_1}{C_1} + \frac{X_2}{C_2} + \frac{X_3}{C_3} \ldots = 1$$

the specimen would break.

In the case of Preston's glass test pieces, the stress was above the long time breaking point and final failure was certain. This is somewhat analogous to the above when one stress cycle represents one unit of time. It is not too great a flight of the imagination to postulate that a graph representing the development of breakage in Preston's glass test pieces would show a nest of parallel lines representing the stress just as did Peterson's, although their shape would probably be different.

If they are parallel, then the same reasoning will apply and it will not be necessary to know anything else regarding the mechanism of breakage. Proceeding with the assumption that the lines are parallel, then the reciprocal of the breaking time at any stress is the weakening effect produced per unit of time at that stress. This would be true in the case of Black or Preston, but Black's result is always the summation of a series of stresses and is, hence, not amenable to treatment. However, Preston's work may be tested and transformed into a series corresponding to Black's and if these come out parallel, then it is at least indicative that the breaking effect is proportional to the time at any stress.

Preston's two tables have been plotted in Fig. 13 with breaking strength as ordinates and log time as abscissas. The line drawn through the points has been extrapolated long distances to increase the stress range. By means of this figure the breaking time corresponding to any stress can be read and the value of 1/T obtained. Thus at 4000 lbs./sq. in. stress, log T = 7.95, 1/T = .000,000,011,2. At 4100, log T = 7.42, 1/T = .000,000,038. If each stress were maintained one second, the weakening effect would be the sum of these two or .000,000,049 part of the breakage. This is the same as if the stress had increased at the rate of 100 lbs. per sq. inch per second from 3950 to 4150 lbs. per sq. inch. If the value of 1/T is found for each 100 lbs. stress interval and summed, the result will give the breaking effect which would be produced in Preston's test pieces if the stress had been increased at the rate of 100 lbs. per square inch per second.

This has been done for the data in Table X. (Lower curve Fig. 13.)

The upper curve has been summed for 200 lb. stress intervals and therefore corresponds to a rate of stressing of 200 lbs. per sq. in. per second.

TABLE XIII. SUMMATION OF STRESS-BREAKING EFFECT PER UNIT TIME FROM UPPER CURVE FIGURE 13 SUMMED FOR RATE OF 200 LBS. PER SQ. IN. PER SEC.

| *Stress, lbs. p. s. i.* | *Sum* |
|---|---|
| 6000 | .00000002 |
| 200 | .000000137 |
| 400 | .000000674 |
| 600 | .00000281 |
| 800 | .00000957 |
| 7000 | .0000286 |
| 200 | .0000733 |
| 400 | .000173 |
| 600 | .000372 |
| 800 | .000771 |
| 8000 | .001463 |
| 200 | .00256 |
| 400 | .00430 |
| 600 | .00687 |
| 800 | .01085 |
| 9000 | .0161 |
| 200 | .0233 |
| 400 | .0329 |
| 600 | .0455 |
| 800 | .0613 |
| 10000 | .0808 |
| 200 | .1048 |
| 400 | .1343 |
| 600 | .1698 |
| 800 | .2125 |
| 11000 | .2626 |
| 200 | .3228 |
| 400 | .3936 |
| 600 | .4768 |
| 800 | .5701 |
| 12000 | .6773 |
| 200 | .797 |
| 400 | .9327 |
| 600 | 1.084 |
| 800 | 1.250 |
| 13000 | 1.445 |
| 200 | 1.664 |
| 400 | 1.904 |
| 600 | 2.173 |
| 800 | 2.475 |
| 14000 | 2.814 |
| 200 | 3.194 |
| 400 | 3.601 |
| 600 | 4.048 |
| 800 | 4.538 |
| 15000 | 5.075 |
| 200 | 5.677 |
| 400 | 6.338 |
| 600 | 7.063 |
| 800 | 7.839 |
| 16000 | 8.691 |
| 200 | 9.623 |
| 400 | 10.623 |

Breaking effect may be read directly only for the rate at which the effects were summed. All of the breaking effect will be exhausted when the sum reaches one (1.0), since T is the breaking time and the sum would then be $T \div T = 1$.

If the rate of increase of stress were increased then the

time spent at each 100 lb. stress interval would be decreased in exact proportion. Thus, if the rate is doubled, the time spent at each stress interval will be halved. The specimen would break under these conditions when the sum in the table reached two (2). This may be written

$$\text{Required sum in table} = \frac{R_1}{R_o}$$

where $R_1$ = Rate of increase of stress desired
$R_o$ = Rate of increase of stress in table
both expressed in lbs. per sq. in. per second.

This method was followed in obtaining the various points in the two curves of Preston's glass shown on Fig. 15. If the theory of the above method is correct, Preston's transformed curves and Black's curve should be parallel. While the curve for Preston's ¼" x 2" x 16" laths ($P_1$ Fig. 15) has a somewhat greater slope than the other two, it is believed that the three curves are as nearly parallel as could be expected when the great difficulty of obtaining reproducible data is considered and the unavoidable inaccuracies of the process of transforming Preston's curve are considered. The author believes that the theory is therefore substantiated as far as these data are concerned. It is worthy of note also that two of the graphs for the electric light bulbs, namely B clear and B frosted on Fig. 16 have very nearly the same slopes.

This theory, if correct, enables any problem involving the strength-time relation to be solved. A few examples may be of interest—

*Examples:*

1. Find the strength of Preston's plate glass when the rate of loading is 25 lbs. per minute.

Reducing to units of stress (S)

$$S = \frac{25\# \times 16'' \times 6}{4'' \times 2'' \times (1/4)^2} = 4{,}800 \text{ lbs./sq. in./min.}$$

$$S = \frac{4{,}800}{60} = 80 \text{ lbs./sq. in./sec.}$$

$$\text{Req'd Sum} = \frac{R_1}{R_o} = \frac{80}{100} = .8$$

Strength corresponding to .8 (Table XII) = 10,250 lbs./sq. in.

2. Let the loading rate be 100 lbs./min.

Rate of stress = 19,200 lbs./sq. in./min.
= 320 lbs./sq. in./sec.

$\frac{R_1}{R_o} = 3.2$. Strength = 12,060 lbs./sq. in.

Breaking time (from zero load) =

$$\frac{12{,}060}{19{,}200} = .628 \text{ minutes}$$

3. Let the loading rate be 1 lb. per minute and let an initial load of 35 lbs. hang on the specimen for 65 seconds before the uniform rate is started. Find
   (a) The av. breaking strength
   (b) The av. breaking time
   (c) The av. breaking load
   (d) The difference in the breaking strength and that which would be found if the 1 lb. rate had started from zero.

The first step is to find the part of the breakage (weakening effect) of the steady load, as follows:

Stress at 35# load = 6,720 lbs./sq. in.

$$\text{Breaking effect} = 65 \times \frac{1}{T} \text{ (at } 6{,}720) =$$

$$65 \times .001718 = .01117$$

Breaking effect remaining = 1.00000 — .01117 = .98883

(a) The breaking effect due to the gradually increased load of 1 lb./min. is .98883 instead of 1.00000. In this example the initial stress is 6,720. The part of the table below this stress decreases the breaking effect in Table 12 corresponding to the breaking strength. The breaking effect between any two stresses in the table is evidently their difference, and since the time spent at any stress interval is inversely proportional to the rate,

$$(\text{Sum Req'd} - \text{Sum at } 6{,}720) \frac{R_o}{R_1} = \text{the breaking effect}$$

This must equal .98883.

The rate of stressing due to 1 lb./min. $R_1 = 3.2$ and $R_o =$ 100 lbs./sq. in./sec. and the sum in the table at 6,720 stress is .00972. $\therefore$ Sum req'd $= \frac{3.2}{100} \times .98883 + .00972 = .04136$.

Breaking strength = 7,588 lbs./sq. in.

(b) The average breaking time is

Loading time = 65 seconds =

$$\frac{7{,}588 - 6{,}720}{3.2} + 65 \text{ seconds} = 336 \text{ seconds} = 5.6 \text{ minutes}$$

(c) The average breaking load will be that which would give a stress of 7,588 lbs./sq. in. It equals 39.5 lbs.

(d) If the 1 lb. rate had been started from zero the required sum would be

$$\text{Req'd Sum} = \frac{R_1}{R_o} = \frac{3.2}{100} = .032$$

Strength = 7,418

The difference = 7,588 — 7,418 = 170#

*Note:* In this example the static load at the start partly counteracts the breaking effect lost by starting with the 35# initial load.

These examples indicate how the curve relating strength with time may be used to gain an insight into many of the errors found in tests which have been published in the literature. Several experimenters have entirely neglected to transform their loads into stresses and hence the effect of the stress time relation has been missed entirely. Holland and Turner[23] made this mistake when they worked out the relation between *width of test piece* and *Breaking Strength* and then used these data to find the theoretical strength of glass. They used a constant rate of loading and hence the rate of stressing varied from 16,000 lbs. per sq. in. per min. in the wide specimens to 47,150 lbs. per sq. in. per min. in the narrow ones. Moreover the change of size entered into the result

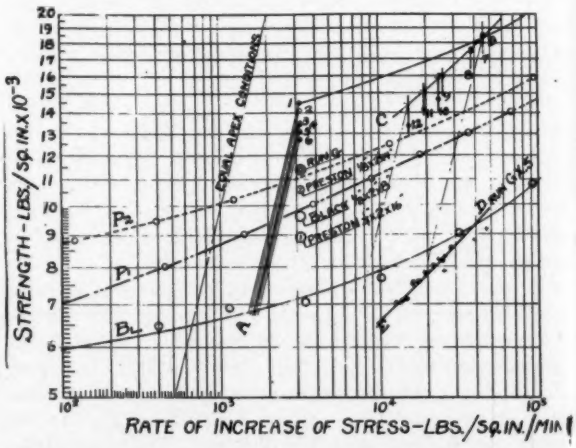


**Fig. 15. Comparison of the strength of glass found by several investigators with that of "Run G" when the major factors of strength are considered.**

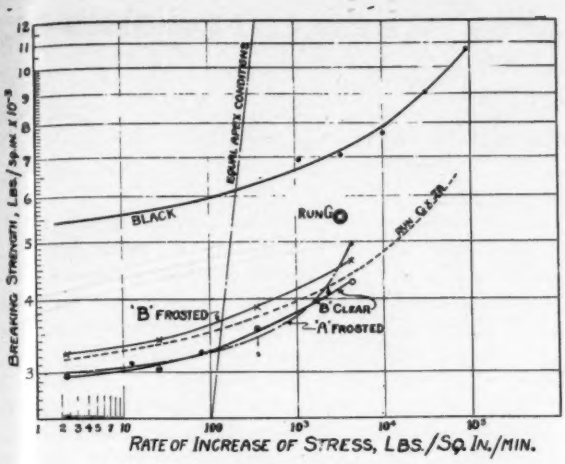


**Fig. 16. Comparison of Black's curve and the strength of electric lamp bulbs due to McCormick.**

the effect of the "Area Function" making it very difficult to study either factor. Their computation, therefore, does not indicate the theoretical strength of glass. It indicates the theoretical strength of an infinitesimal specimen tested at an infinite rate of stressing.

Nearly all the pressure tests on bottles are devoid of any stress function. The size and weight of the bottle are usually given along with the bursting pressure, but the thickness of the wall is completely overlooked. (One would hardly expect a steel mill to sell pipe or pressure cylinders on a size and weight basis alone.)

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[28]"The Effect of Width on the Breaking Strength of Sheet Glass," Jo. Soc. Gl. Tech. Vol. XX, No. 78, April, 1936, Pp. 72-83.

*(To be concluded in April)*

## BOOK REVIEW

• "Glas und Fenster" ("Glass and Windows"), by Otto Völckers. Published by Bauwelt Verlag, Berlin, 1939. 8½ x 11½ inches. 128 pages. 178 illus.

Here is a book in which some fine photography has been reproduced, together with a brief but thoroughly scientific discussion of the highly important subject of good window lighting. As a printing job, it is superlative. A simple, clean-cut type face has been used and the columns run the full width of the page. The photography is well-nigh perfect. The pictures were taken with the object of bringing out architectural and structural applications of window glass and the types of lighting and light distribution, good and bad, resulting from various arrangements of windows.

In addition to the halftones, the book contains numerous drawings in isometric projection, reproductions of old wood-cuts, and schematic drawings and graphs, bringing out the principles of good lighting.

The association of German flat glass manufacturers, who present this book as a souvenir of the year of the Third Congress on Glass, in Germany, have permitted the author to develop to the full his thesis that "the window is the soul of all Northern European architecture, and glass is the soul of the window." He starts with an interesting chapter on the development of windows and window glass from the beginning, and traces the window from its origin as a mere slit or hole in the wall to its present high importance in all buildings occupied by men. In this section appears a picture of Sixteenth Century glassworkers making disks of crown glass, so realistic that one might think it especially posed. It is photographed from a model in the German museum in Munich. A few pages farther on, the Lubbr's process is illustrated. One wonders why mouth-blown cylinders are not also depicted, and why the illustrations of casting plate glass show only the eighteenth century procedure, with crowds of workmen in their long dusters. The Fourcault process is illustrated very clearly by photographs of museum models and actual operations.

In the section devoted to German architecture and its windows, up to the twentieth century, a splendid impression is given of the way in which windows have increased in importance, in effectiveness, and in ornamental effect, through the years.

The third and most important section of the book discusses the modern window. It is written from the point of view of northern Europe, where the hours of sunlight in the winter are so few that every effort must be made to take advantage of them. This applies equally well to large areas of our own country. Adequate lighting seems not yet to have been thoroughly defined, in the writer's opinion. It involves not only a ratio of window space to floor space, at least as high as one to five, as he thinks, but also a proper adjustment of a window as to proportion between height and breadth, all of which is excellently brought out in schematic diagrams on which photometric measurements are plotted.

The great importance of good lighting for health, for efficient work, and for the profitable housing of livestock is well demonstrated. The author brings out the limitations of window glass as a transmitter of ultraviolet radiation; and shows, without apology, how little can be done by way of stopping infra-red radiation by loading the glass with iron, without at the same time making its ultra violet transmission quite feeble.

No little attention is given to greenhouses and forcing frames for raising early vegetables, which seem to have come into a great deal of importance in Germany.

A number of photographs show some of the more modern factories, schools, and hospitals, in which outer walls are composed almost entirely of windows. A feature of indoor lighting that is perfectly demonstrated in this photography and emphasized in the text is the rapid decrease in light intensity with distance from the windows in rooms lighted from one side.

The book is a strong sales talk for window glass. Statistics are presented which show that 18.5 million square meters of mouth-blown window glass were produced in Germany in 1925 with practically none at the present time, while in the same period machine-drawn window glass came up from 0.4 to 29.5 million square meters. A bibliography with 93 references completes the work.

American periodical literature has many examples of similar richness of illustration and beauty of printing, which might well be called upon to illuminate the prose of our technical books.—S. R. S.

# AUSTRALIAN PLANT UTILIZES MEEHANITE METAL

**By E. OLFEN**

**Production Engineer, Australian Glass Manufacturers Company, Ltd.**

During the past few years some unusual experiments have been made by the Australian Glass Manufacturers Company Ltd., Sydney, Australia, in order to ascertain to what extent and with what success Meehanite metal could be used for making glass moulds and in glass machinery castings. Meehanite metal is a metallurgically-controlled casting metal produced by formulated methods, so that the finished products will meet definite requirements. Specifications may be individually drawn to meet the service requirements and production uniformity is such that the mechanical and physical characteristics of the metal may be repeated from heat to heat.

Results from these tests were favorable and the company now operates its own foundry, using about twelve tons of Meehanite castings per week for a wide variety of applications. The plant produces all types of bottles, hollow-ware, tableware, pressed and blown ware, sheet glass, figured rolled glass, cut glass, and lighting-ware.

Bottle and glassware moulds as illustrated in Figs. 1 and 2, provide examples of increased production life and other economies resulting from the adoption of this metal by the Australian company. These moulds are, of course, subjected to severe treatment, since the skin temperature of the inside reaches about 1800 deg. F., while the outside may reach only 750 deg. F. Such a temperature difference between surfaces sets up severe internal stresses, accentuated by the blowing of cold air on the moulds to cool them. Resultant scaling and growth of the moulds have been largely reduced by the adoption of Meehanite, the grain structure being controlled to provide a uniform density, eliminate spongy spots, and retain machinability.

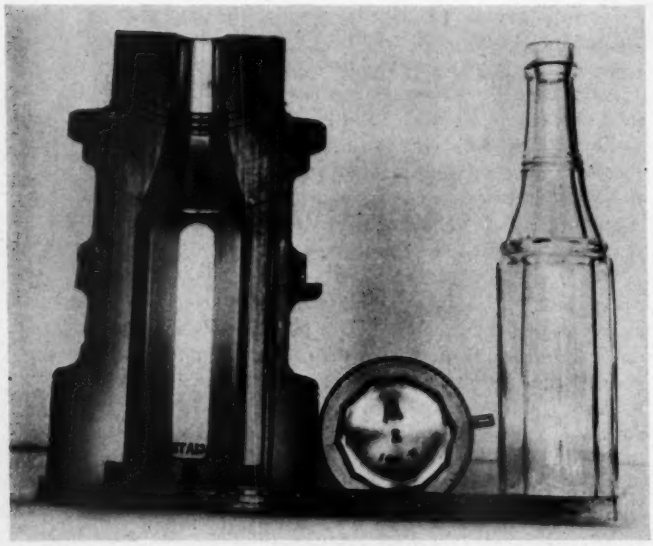


**Fig. 1. Bottle mould from Meehanite metal.**

Greater production capacity is illustrated by tests on a plunger used for the manufacture of Pyrex funnels, shown in Fig. 3. This Meehanite plunger was able to run nine hours, as compared to four hour runs for previous plungers, and plans for the replacement of all pyrexware mould equipment with Meehanite are now under way.

The metal can be cast to accurate sizes and shapes, so additional economies are possible in the mould shop. It was found that certain intricate pressware moulds could be cast to the correct size and shape, using plaster or monolith cement patterns of exact dimensions. Only a small chipping or machining strip was required on the joints and casting faces, and sizable reductions in machining and finishing operations were achieved.

Figs. 4 and 5 show cast-out moulds and indicate the difficult types that have been simplified by casting true

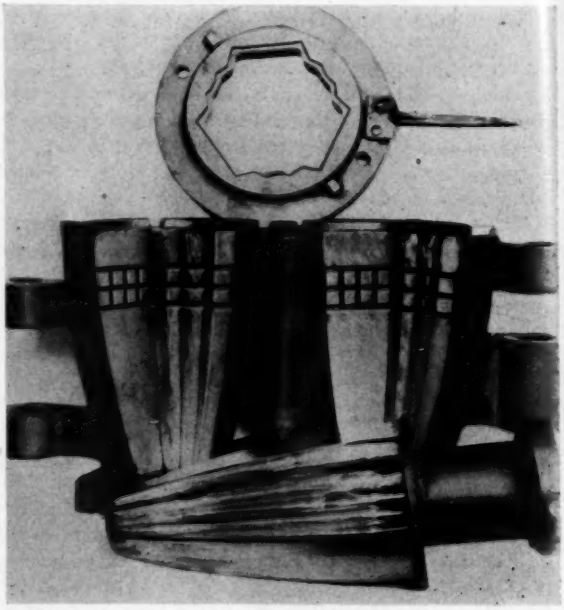


**Fig. 2. Meehanite mould for pressed glass vase.**

to shape and to accurate dimensions. The glass spoon mould and the motor car headlight lens plunger ordinarily represent two particularly knotty problems. As a general rule, such moulds require considerable mould finishing.

Substitutions were also made in glass machinery parts. Alloy-steel glass crusher rolls were replaced with Meehanite, using a tough, wear-resisting grade, cast into an iron chill, as shown in Fig. 6.

Although the skin surface of these rolls was extremely hard, it was possible to machine them with tungsten carbide tools. After seven months' service, during which

Fig. 3. Plunger for pressing glass funnels.

10,000 tons of glass were crushed, no wear of the crusher teeth was noticeable. Further improvement in wearing life was found in the increased service given by a pinion casting for a glass batch mixer after conversion to Meehanite. Operating life jumped from two weeks to four months.

Bottle mould machine tables requiring gear teeth which are subjected to severe stress through rapid stopping and starting (64 stops per minute) generally lasted about twelve months until Meehanite tables were substituted. After six months' steady operation, the teeth of the new tables were checked with vernier tooth calipers and showed such slight wear that it was evident that table life would be doubled. A 12-inch and a 5-inch glass roller used in the production of figured rolled glass provided equally desirable results after conversion.

Experiments are being continued with the aim of extending still further the increased efficiency and lowered production costs made possible by these previous tests. Indications are that improvements in production practice, secured by the careful selection of casting materials, will be widespread throughout the plant.

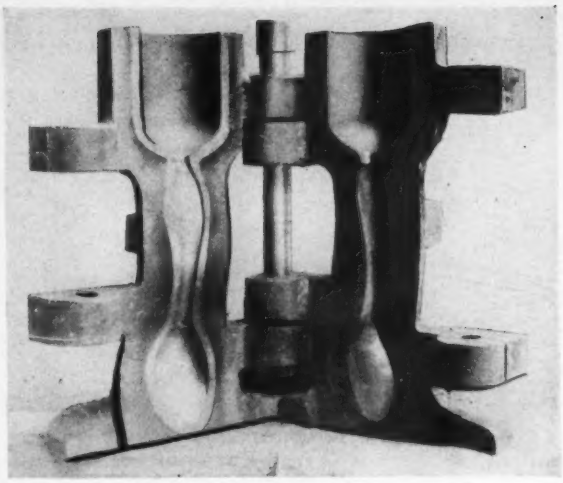


Fig. 4. Glass spoon mould cast to shape.

Fig. 5. Mould equipment for automobile headlamp lens. The plunger was filed and polished after being cast to size and shape.

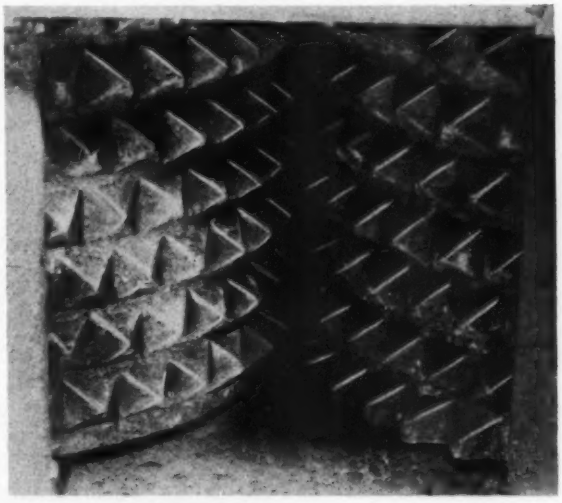
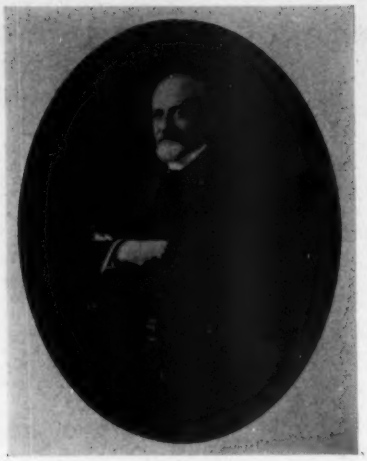


Fig. 6. Meehanite crusher rolls after 7 months' service.



**LUCIEN DELLOYE, 1856-1938**

The death of Lucien Delloye, former Director-General of the Saint-Gobain Glass Works, in Paris on December 25, 1938, is a great loss to the glass industry. Starting his active career in 1881 as a mechanical engineer with the Saint-Gobain Works, in 1882 he invented the first circular polishing table of large dimensions, which in connection with the circular grinding system, constituted the first modern grinding and polishing equipment for the making of plate glass. This was the first real progress in the glass industry since 1830. In addition to his technical achievements, M. Delloye was responsible for the establishment of glass plants in Italy, France, Belgium, Spain and Holland.

**RELATIVE SOLUBILITY OF GLASS AS INDICATED BY DYE ABSORPTION**

A knowledge of the amount of material that may dissolve from the inner surfaces of glass bottles and contaminate the contents is important in the "packing" of solutions, the compositions of which should remain unchanged for considerable periods of time. One important group of such solutions includes medicinals, serums, antitoxins, and solutions prepared for intravenous injections. Numerous tests to determine solubility have been specified, but so far there is not much agreement between them.

Since the problem is of importance to the several medical agencies of the Government, E. H. Hamilton and A. N. Finn of the Bureau have been conducting tests along lines somewhat different from those ordinarily followed, and they have tentatively arrived at the conclusion that the relative solubility can be determined by the amount of dye absorbed on the surface of "flint" green and blue glass bottles after treatment with neutral or acid solutions. Amber glasses do not react.

The method is, briefly, as follows: Wash the bottles, on the inside, with soap and water, then with 1 per cent acetic acid, and finally three times with distilled water. Fill the bottle with 0.05 molar potassium acid phthalate adjusted to pH 6 with sodium hydroxide, digest at 80° C for 24 hours, remove the solution, and wash the bottle with distilled water. Fill the bottle with 0.06 per cent aqueous solution of victoria blue (C.I. 729), let stand for 30 minutes, remove the dye solution, and rinse with hot distilled water. Dissolve the dye absorbed by the surface of the glass with cold 95 per cent ethanol and determine the concentration of the dye in the ethanol solution with a reliable color comparator. The relative solubility of the glass is indicated by the amount of dye absorbed by bottles of similar size and shape.

The reliability of this method was demonstrated by testing bottles of the same shape and size made from different kinds of glass. The bottles were furnished by manufacturers who knew from practical experience and their own laboratory tests the relative solubility of the glasses. In every case, the dye test indicated the same order of relative solubility as reported by the manufacturers. When bottles of different shape or size are tested, results can be compared only on a unit area basis—a fact too frequently overlooked when a test for solubility is described without reference to the volume and area of the bottle.—*Technical Bulletin of the National Bureau of Standards, January* 1939.

**HAND-MADE CARBON LAMPS AT SAN FRANCISCO**

A feature of the General Electric exhibit at the Golden Gate International Exposition in San Francisco is a demonstration of the hand manufacture of old-time carbon-filament lamps. In most particulars the process follows the methods by which Thomas A. Edison produced the world's first practical incandescent lamps.

The demonstrator is Charles S. Ault, recently retired on a pension by the G. E. incandescent lamp department at Nela Park, Cleveland, after 48 years of continuous service devoted to lamp making. To speed up the painstaking process of making the replicas of Edison's first lamps, the veteran lamp-maker is provided with such finished parts as filaments, leading-in wires and wooden bases. Even so, the assembly of the lamp by hand consumes a full hour, most of this time being devoted to glass firing, moulding, filament mounting and bulb blowing.

As shown in the accompanying illustration, Mr. Ault's method for producing the glass lamp bulb is somewhat different from Edison's, since he utilizes glass tubing, but the result is practically identical. Other detail operations include making the stem, inserting the leading-in wires, mounting the filament, assembly of stem and bulb, exhausting of air from the lamp, sealing, and finally mounting in the old-style wooden base. The finished lamp is connected to the electrical circuit and lighted, a replica of the first incandescent lamps, produced by Edison when Mr. Ault was only eight years old.

# NOTE ON USE OF CAUSTIC ALKALI IN GLASS BATCHES

By A. E. BADGER and L. M. DONEY*

The use of caustic alkali (NaOH) as a source of soda in glass batches is not advisable in plant practice due to the danger of skin burns from caustic and also to the fact that the hygroscopic nature of this material would create a storage problem.

As a laboratory curiosity, however, the use in the glass batch of part of the soda as caustic alkali might produce a difference in the fining properties, since the decomposition of caustic would have a tendency to introduce water in the glass with a possible change in viscosity. To determine whether any change in fining properties would result from the presence of NaOH in the batches, several melts were made in small (4 inches high) porcelain pots, a temperature of about 2500°F. being maintained for about 2 hours.

In one series of tests, a soda-lime bottle glass was made from a batch in which the soda was introduced as soda ash ($Na_2CO_3$). This glass was then compared with the same composition made from batches in which ¼, ½, ¾, and finally all the soda was introduced as caustic alkali. No apparent difference in the fining of these glasses could be noticed. The final melt in which no soda ash was used formed a glass which was hygroscopic, a film forming quickly on its surface.

Salt (NaCl) has been introduced intentionally in glass batches as a fining agent. In other cases, it is of accidental occurrence as an impurity in sand, salt-cake or soda ash. Although small amounts of caustic alkali had no apparent effect on the fining of the glasses mentioned above, its use in batches containing salt might promote the following reaction, namely,

$$NaOH + NaCl + SiO_2 = Na_2SiO_3 + HCl$$

If this reaction occurred, the fining properties of glass would be changed by the more rapid disappearance of salt.

Some preliminary tests indicated that the presence of caustic alkali in a batch containing salt did affect the fining properties of the glass and consequently the following series of glass batches (Table 1) was melted at about 2550°F. for 2 hours, using porcelain pots as in the above.

TABLE 1

| No. | *Sand* ($SiO_2$) | *Lime* ($CaCO_3$) | *Soda ash* ($Na_2CO_3$) | *Salt* (NaCl) | *Caustic Alkali* (NaOH) |
|---|---|---|---|---|---|
| 1 | 72.0 | 21.4 | 27.4 | 0 | 0 |
| 2 | 72.0 | 21.4 | 27.4 | 0.3 | 0 |
| 3 | 72.0 | 21.4 | 24.0 | 0.3 | 2.58 |
| 4 | 72.0 | 21.4 | 20.5 | 0.3 | 5.16 |
| 5 | 72.0 | 21.4 | 17.1 | 0.3 | 7.74 |

Neglecting the small quantity of salt used in Nos. 2-5, the batches in Table 1 form glasses of the same chemical composition, various amounts of caustic alkali being substituted for equivalent amounts of soda ash. However, the number of seeds in the melted glasses differed in that Glass No. 2, containing salt without caustic alkali, had innumerable fine seeds while Nos. 1, 3, 4 and 5 were nearly plain. The conclusion may be drawn that the presence of NaOH in the glass batches containing salt aided the elimination of salt from these glasses in some manner, perhaps that suggested by the chemical equation given above. This conclusion was checked by two other melts of this series of glasses, which were made at about 2625° F. for about 2 hours. In these cases also, the No. 2 glass was more seedy than the others which had the same heat treatment.

Although the glass containing salt was more seedy than a salt-free glass, the value of salt as a fining agent is not questioned by these results. In commercial practice, enough time is available for salt to volatilize and perform its fining action. The small-scale melts described here indicate only that the rate at which salt is eliminated from a glass melt is accelerated by the presence of small amounts of caustic alkali.

*Dept. of Ceramic Engineering, Engineering Experiment Station, University of Illinois.

## NEW PROJECTOR LAMP INCORPORATES HEAT-RESISTING GLASS

Designed for a multitude of indoor and outdoor projection and flood-lighting applications, a new projector lamp recently announced by the General Electric Co. combines all the elements necessary for the production of controlled light within a single sealed element. An interesting feature of the lamp is the use of heat-resisting glass to withstand the wide range of temperature changes and physical shocks to which it may be subjected in both indoor and outdoor service.

The new lamp embodies a pressed reflector and a light-directing cover lens, also pressed. In the manufacture of the lamp, the inner surface of the reflector is metalized to a mirror finish and the filament is fixed in exact position. The cover glass is frosted on the inside. Then the two sections are fused together, so that the elements of the lamp are held in perfect adjustment and hermetically-sealed against dirt and moisture. Two types of cover lenses are now available, one giving a wide-spread beam for general floodlighting and the other providing a powerful narrow beam for spotlighting applications. The lamp has a 150-watt filament of the high-efficiency type, with a rated life of 1,000 hours, and employs a medium screw base that fits the conventional socket.

Supplementary cover lenses, which snap over the front of the bulb, can also be used. These include a dark-glass cover that transforms the projector into a heat lamp; prismatic cover lenses to change the beam pattern; and color lenses to provide any desired color of light.

## SILVERMAN LECTURES

Dr. Alexander Silverman, head of the Department of Chemistry in the University of Pittsburgh, lectured on "Newer Glass Developments" during the week of February 13 for the American Chemical Society. In addition to a discussion of new products, demonstrations were given to illustrate infra-red and ultra-violet light phenomena.

# ARSTRACTS OF SOME PAPERS PUBLISHED DURING THE LAST SIX MONTHS IN GERMANY

### The Significance of Glass as a Material in Production and Use

Dr. Maurach, the Secretary of the German Society of Glass Technology, who has a distinct flair for statistics and their graphic presentation, contributes to the August, 1938, number of *Berichte* an entertaining discussion in which manufacture and use of glass in Germany, as compared with other countries, is attractively presented.

We present from this article Fig. 2, which is a clever schematic diagram developed on the basis of weight and showing the relative tonnage of raw materials, classified as chemical and natural; cullet originating in the factory and from used glass; the melting loss of 23 per cent, resulting in a yield of molten glass rated at 100, which becomes flat glass, 31; hollow ware, 49; and cullet returned, 20. The partition of this stream of product between export and domestic use is also indicated.

A statistical diagram setting forth the position of the various nations as glass producers shows the outstanding position of the United States and the somewhat surprising fact that Russia appears in second place. However, we are informed that since the acquisition of Austria and part of Czechoslovakia, Germany is now in second position.

Some figures on the number of workers engaged relative to the tonnage of glass produced in different countries are entertaining. Some selected items are drawn from this tabulation, as follows:

| *Country* | *Number of Workers* | *Glass in 1000 T.* | *Tons per Workman* |
|---|---|---|---|
| United States | 67,000 | 3,000 | 44.0 |
| Russia | 106,000 | 1,000 | 9.5 |
| Germany | 59,400 | 727 | 12.2 |
| England | 50,000 | 550 | 11.0 |

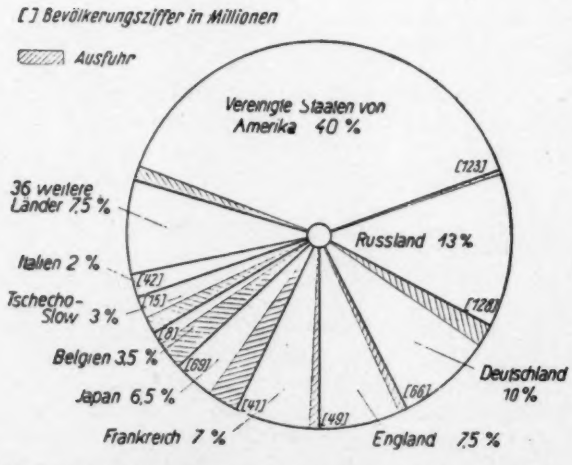



**Fig. 1. How the nations share the world's glass production. Population is shown in millions. Cross hatching shows the exports of glass from each nation.**

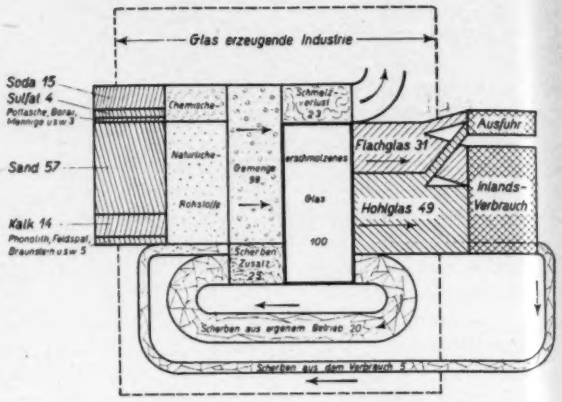



**Fig. 2. Tonnage flow diagram of German glass manufacture.**

### The Coloring Substance in the So-Called Carbon Yellow Glasses

Neumann and Dietzel (*Glastechn. Ber.*, Dec., 1933) have renewed an attack on the problem which, as they say, has vexed glass technologists for seventy years or more; namely, whether or not the carbon is directly concerned in the production of the so-called carbon yellows, or carbon ambers.

*Introduction:* If the usual commercial alkali-lime glasses are melted with addition of carbonaceous materials or under a reducing fire, there is produced a yellow or brown coloration ("carbon amber").

On the question concerning the coloring material in these carbon-amber glasses, one may find a series of publications without, however, any definite clarification up to the present time. Today it is a problem as to whether finely divided carbon or, rather, sulfides, are the coloring agents. In the past century chemists have worked on this.

Notably in 1875, Penroth stated the problem in these words, "This yellow-brown coloration originally obtained by reduction of sulfates of the batch remains lately, if indeed its original is not falsely assumed, still the most confused, as it is in our day the most frequently used method. It was obtained by the older authors directly as an addition of organic material; and then through using reducing conditions as expressed above was first recognized by the investigations of Splitgerber and Pelouze, but the information learned from these studies taught, however, that the alkali sulfide formation in the furnace, necessary for the production of the yellow, was influenced by so very many conditions. . ."

Pelouze found, for example, that reducing agents of different sorts: carbon, hydrogen, etc., brought out in commercial glasses one and the same yellow coloration, and that these were conditioned by alkali sulfides. Griesheimer wrote about the coloring power of iron sulfide. Heinrichs and Becker investigated the formation and stability of iron sulfide in glass without, however, deciding whether this color was identical with the known

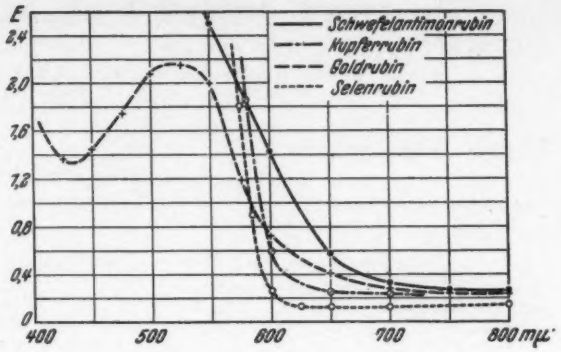
carbon amber. Springer made carbon responsible for the color. This view was supported by Fedjeff and Lebedeff. In 1930 Bork disputed this view, and established that no yellow coloration could be produced with raw materials completely free from iron and sulfur; on the contrary, that it came about immediately if only traces of iron and sulfur were present. Here, for the first time, the carbon-amber color (in the observed case) was ascribed to iron sulfide. Jebsen-Marwedel and Becker came eventually to the conclusion that carbon does not color alone, but only in the presence of sulfur. If Weckerle maintained that it was possible to get pure carbon coloration in soft glasses, he also viewed iron sulfide as the colorant in normal technical glasses. In a work on defective glasses, Hundeshagen made sulfides or polysulfides responsible for the amber coloration. He reported on one case where, in consequence of local strong reduction by carbon, a black bottle glass came about instead of a green one. "Here was the black coloring principle of iron sulfide. . . . Upon analysis of the glass, not only sulfides, but also definitely polysulfides and carbonaceous substances were found." Here is voiced, therefore, for the first time, the problem whether iron sulfides and polysulfides may produce color together. How they with any certainty could be identified and separated, we are unable to state.

Fuwa reported recently several experiments on glasses which were colored by carbonaceous materials. In two reports he determined carbon analytically in these glasses, and came to the conclusion that the glass was colored by colloidal carbon. Hence we are brought to a standstill with the problem of carbon yellow as we were fifteen years ago.

This problem was attacked recently in order to attempt to bring it to some clearer conclusion. Our experiments were directed primarily to the testing of the analytical procedures of Fuwa and to the preparation of "carbon" yellow glasses under conditions of complete exclusion of carbon and its compounds. In a second paper we shall investigate how the pure alkali polysulfides color glasses, and finally, in a third part, it will be established how iron sulfide makes colors, and in what relationship to the polysulfides the carbon yellow glasses stand under different circumstances.

### The Presence of Sulphur, Selenium, and Tellurium in Glass

Dr. Dietzel, in *Glestechn. Ber.* for September, 1938, summarizes present-day knowledge and opinion concerning the behavior of these related elements. Selenium, he says, is best investigated; and it may be found in glass as the free element, as the selenide, polyselenide, selenite, or selenate. There is a definite parallelism between the stages of oxidation of selenium as it exists in glass and in water solutions, from the point of view coloring effect, and essential reactions. Relationships are similar for sulphur and tellurium, but the differences lie in the following considerations. The limits of stability of the different stages of oxidation are spread, in comparison with selenium. It thus arises that sulphur precipitates out at a lower $p_H$ value of the solution and tellurium at a higher $p_H$ value than selenium. One would therefore expect to get elementary sulphur in a relatively more acid melt, and tellurium in a somewhat more basic melt. From these considerations it may be further deduced that the polysulfides are unstable in ordinary glasses, whereas the polyselenides and tellurides, on the contrary, are not. Apparently sulphur blue (ultra marine) is to be regarded as analogous to the selenium rose. Free tellurium in glass is not comparable with sulphur and selenium; it separates out as a colloid.




**Absorption curves for ruby glasses. (Dietzel.)**

### Ruby Glass with Antimony Sulfide

Dr. Dietzel reports also, in the October, 1938, *Berichte*, on the application of antimony sulfide as a colorant, and remarks that only cadmium sulfide and iron sulfide have hitherto been well understood. Most other heavy metal sulfides give muddy colors. It has thus far been scarcely recognized that glass may be colored deep red with antimony sulfide if a properly compounded melt is used. When in the simple glass $SiO_2$ 74 per cent, $Na_2O$ 18 per cent, CaO 8 per cent, as much as seven parts of flowers or sulfur and five of antimony sulfide are used per hundred of sand, results were obtained by Hohlbaum, but the author prefers to use $Sb_2O_3$ along with elementary sulphur and carbon so that he may change the degree of oxidation or reduction at will. Heat treatment at 600-700°C. develops the color; and when antimony oxide is present to the extent of 0.8 to 1.5 per cent, together with about 1.5 per cent sulphur and an equal addition of carbon, the glass can be struck to a deep red color.

The absorption curve of the resulting glass, compared with curves for other rubies, shows a sharper cut-off than for gold, but rather more transmission for the wave lengths shorter than 550 mμ than for copper or selenium. This diagram is reproduced below.

### Sound Waves for Removing Bubbles From Melted Glass

In the July, 1938, *Berichte*, Dr. Kline and Dr. Kruger report independently on their success in causing small bubbles to coalesce and thereby to form larger bubbles and rise from viscous liquids under the influence of sound waves, "supersonic" in character, having a frequency of about 16,000 per second. No technical application is claimed for the procedure as yet, but it is recognized that a great deal of experimentation will first be necessary.

# CURRENT PRICES OF GLASS-MAKING MATERIALS

**FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS**

## Base Materials

| | | Carlots | Less Carlots |
|---|---|---|---|
| Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh | ton | 43.00 | 46.00 |
| Barium sulphate, in bags | ton | 19.00 | 24.00 |
| Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point | ton | 15.00-16.00 | 18.00 |
| Borax ($Na_2B_4O_7 10H_2O$) | lb. | .... | .... |
| Granulated | In bags, lb. | .0215 | .027 -.0295 |
| Powdered | In bags, lb. | .024 | .0295-.032 |
| Boric acid ($H_3BO_3$) granulated | In bags, lb. | .043 | .054 -.0565 |
| Calcium phosphate ($Ca_3(PO_4)_2$) | lb. | .07 | .07½ |
| Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith) | lb. | .0865 | .0925 |
| Synthetic (Artificial) | lb. | .0825 | .0875 |
| Feldspar— | | | |
| 20 mesh | ton | 11.00-13.25 | |
| 40 mesh | ton | 11.50-13.75 | |
| Granular | ton | 11.75-14.00 | |
| Semi-granular | ton | 11.00-13.25 | |
| L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags | | | |
| Fluorspar ($CaF_2$) domestic, ground, 96-98% (max $SiO_2$, 2½%) | | | |
| Bulk, carloads, f. o. b. mines | ton | 28.00 | .... |
| In bags | ton | 29.60 | 38.00-40.60 |
| Kryolith (see Cryolite) | | | |
| Lead Oxide ($Pb_3O_4$) (red lead) (N. Y.) | lb. | .0725 | .... |
| In 5 Ton lots | lb. | .... | .0775 |
| Less than 5 Tons | lb. | .... | .0825 |
| Lime— | | | |
| Hydrated ($Ca(OH)_2$) (in paper sacks) | ton | 8.50 | 8.50 |
| Burnt (CaO) ground, in bulk | ton | 7.00 | .... |
| Burnt, ground, in paper sacks | ton | 9.00 | 9.00 |
| Burnt, ground, in 180 lb. drums | Per drum | 1.60 | 1.70 |
| Kiln Dried ($CaCO_3$) 10x30 mesh | ton | 1.75 | .... |
| Kiln Dried ($CaCO_3$) 16x120 mesh | ton | 1.75 | .... |
| Nepheline Syenite, f. o. b. shipping point | ton | 13.00-14.00 | .... |
| Potassium carbonate— | | | |
| Calcined ($K_2CO_3$) 96-98% | lb. | .065 | .0675 |
| Hydrated 80-85% | lb. | .055 | .0575 |
| Salt cake, glassmakers ($Na_2SO_4$) | ton | 15.00 | 25.00 |
| Soda ash ($Na_2CO_3$) dense, 58%— | | | |
| Bulk | Flat Per 100 lb. | .95 | .... |
| In barrels | Per 100 lb. | 1.35 | .... |
| In bags | Per 100 lb. | 1.10 | .... |
| Sodium nitrate ($NaNO_3$)— | | | |
| Refined (gran.) in bbls | Per 100 lb. | .... | 2.50-2.90 |
| 95% and 97% | | | |
| Bulk | Per 100 lb. | 1.35 | .... |
| 200 lb. bags | | 1.415 | 1.44 |
| 100 lb. bags | | 1.45 | 1.475 |

## Special Materials

| | | Carlots | Less Carlots |
|---|---|---|---|
| Aluminum hydrate (A1 $(OH)_3$) | lb. | .029 | .03½ |
| Aluminum oxide ($Al_2O_3$) | lb. | .04 | .07 |
| Antimony oxide ($Sb_2O_3$) | lb. | .11 | .11¾ |
| Arsenic trioxide ($As_2O_3$) (dense white) 99% | lb. | .03 | .03½ |
| Barium nitrate ($Ba(NO_3)_2$) | lb. | .... | .07¾ |
| Pyrophyllite, (20% $Al_2O_3$) | ton | 9.00 | 12.00 |
| Sodium fluosilicate ($Na_2SiF_6$) | lb. | .035-.04 | .04¼-.05 |
| Tin Oxide ($SnO_2$) in bbls | lb. | .... | .50 |
| Titanium Oxide (ceramic grade) | | | |
| In bags | lb. | .12¼ | .12½-.13 |
| In barrels | lb. | .12½ | .12¾-.13¼ |
| Zinc Oxide (ZnO) | | | |
| American process, Bags | lb. | .06¼ | .06½ |
| White Seal, 150 lb. bbls. | lb. | .08¼ | .09 |
| Green Seal bags | lb. | .08 | .08¼ |
| Domestic White Seal bags | lb. | .08½ | .08¾ |
| Red Seal, bags | lb. | .07½ | .07¾ |
| Zircon | | | |
| Refined Granular (Milled .01-.02c higher) | | .06½ | .07-.08 |
| Commercial, Gran. (Milled .01¼-.01½ higher) | | .0225 | .0235 |

## Coloring Materials

| | | Carlots | Less Carlots |
|---|---|---|---|
| Barium selenite ($BaSeO_3$) | lb. | .... | 1.40-1.60 |
| (Commercial, 25% Selenium) | lb. | .... | .85 |
| Cadmium sulphide (CdS) | lb. | .... | .75-.80 |
| Chromite (99% through 200 mesh) | lb. | 35.50 | 40.00 |
| Cerium hydrate— | | | |
| 100 lb. drums and 600 lb. barrels | lb. | .... | .60 |
| Chrome Oxide Green, 400 lb. bbls. | lb. | .... | .22-.26 |
| Cobalt oxide ($Co_2O_3$) | | | |
| In bbls. 350 lbs. or more, | lb. | .... | 1.67 |
| Less than 350 lbs., | lb. | .... | 1.77 |
| Copper oxide— | | | |
| Red ($Cu_2O$) | lb. | .... | .165 |
| Black (CuO) | lb. | .... | .16-.17 |
| Black prepared | lb. | .... | .22 |
| Iron Oxide— | | | |
| Red ($Fe_2O_3$) | lb. | .... | .0425-.09 |
| Black ($Fe_3O_4$) | lb. | .04½ | .09 |
| Iron Chromate | lb. | .... | .035-.05 |
| Lead Chromate ($PbCrO_4$) in bbls. | lb. | .... | .145 |
| Manganese, Black Oxide | | | |
| In Paper bags | ton | 47.50 | 50.50-54.50 |
| In Burlap bags | ton | 49.25 | 51.75-56.75 |
| In Casks | ton | 51.50 | 54.00-59.00 |
| Neodymium oxalate, 50 lb. drums | lb. | .... | 3.50 |
| Nickel oxide ($Ni_2O_3$), black | lb. | .... | .35-.40 |
| Nickel monoxide (NiO), green | lb. | .... | .35-.37 |
| Potassium bichromate ($K_2Cr_2O_7$)— | | | |
| Crystals | lb. | .08¾ | .09-.09¼ |
| Powdered | lb. | .... | .09½-.09¾ |
| Potassium Chromate ($K_2CrO_4$) 100 lb. kegs | lb. | .... | .27 |
| Powder blue | lb. | .... | .17-.2125 |
| Rare earth hydrate— | | | |
| 100 lb. drums | lb. | .... | .35 |
| 325 lb. barrels | lb. | .... | .30 |
| Selenium (Se) In 100 lb. lots | lb. | .... | 1.75 |
| In lesser quantities | lb. | .... | 1.85 |
| Sodium bichromate ($Na_2Cr_2O_7$) | lb. | .06¾ | .07-.07¼ |
| Sodium chromate ($Na_2CrO_4$) Anhydrous | lb. | .08½ | .08½-.08¾ |
| Sodium selenite ($Na_2SeO_3$) | lb. | .... | 1.50-1.65. |
| Sodium uranate ($Na_2UO_4$) Orange | lb. | .... | 1.75-1.80 |
| Yellow | lb. | .... | 1.75-1.80 |
| Sulphur (S)— | | | |
| Flowers, in bbls. | Per 100 lb. | 3.35 | 3.70-4.10 |
| Flowers, in bags | Per 100 lb. | 3.00 | 3.35-3.75 |
| Flour, heavy, in 250 lb. bbls. | Per 100 lb. | 2.90 | 3.25-3.65 |
| Uranium oxide ($UO_3$) (black, 96% $U_3O_8$) 100 lb. lots. Black | lb. | .... | 2.65-2.75 |
| Yellow orange | lb. | .... | 1.75-1.80 |

## Polishing Materials

| | | Carlots | Less Carlots |
|---|---|---|---|
| Emery, Turkish | lb. | .063 | .07 |
| Pumice Stone, | | | |
| American Ground Italian FFF, FF, F | lb. | .... | .03 |
| 0, 0½, ½, 1. | lb. | .... | .03¼ |
| Putty Powder | lb. | .... | .38-.42 |
| Rotten Stone, (Domestic) | lb. | .... | .02 |
| Rouge, Red | lb. | .... | .14 |
| Black | lb. | .... | .16 |

# EQUIPMENT AND SUPPLIES

### FELKER DI-MET GLASS-CUTTING MACHINES

A recent announcement by Musto-Keenan Co., 1801 S. Soto St., Los Angeles, Calif., describes three types of Felker Di-Met machines for glass cutting. Equipped with a special diamond-impregnated blade, the machines are designed to handle various cutting operations from the cutting of thin tubes to the cutting or notching of thick plate or laminated glass, according to the manufacturer's statement.

Model 14-A is a track-type machine in which the cutting unit travels over the work on a track and cuts in either direction. It is adapted for cutting all

types of plate glass, except unannealed, and has a sensitive manual control, together with a clutch for quick traverse. The machine is available with tracks up to 8 ft. in length, providing a maximum cutting distance of 6 feet.

In Model 12-A the cutting unit is mounted on a pedestal and the machine is adapted for notching or cut-off work or for cutting glass cylinders. The cutting mechanism has a 5-in. horizontal travel and a vertical travel of 4 inches. The third machine, Model 11-B, has a rolling table with 10½-in. travel and a vertical adjustment of 5½ in. for the cutting blade. Bulletin G1-39 describes the machines in detail.

### NEW PROTECTO-SHIELD

Willson Products, Inc., Reading Pa., announces a new Proteco-Shield for guarding the faces of workers in light grinding operations, spot welding and other occupations where protection is desirable. It is made of thick transparent cellulose actetate, is well ventilated and large enough to fit comfortably over correction spectacles. The

shield extends well back along the sides of the face and is easily thrown back when not in use. The adjustable molded rubber headband and all other parts are easily replaceable. Shield is available in clear, amber or green transparent cellulose.

### BULLETINS RECEIVED

*Stephens-Adamson Mfg. Co.*, Aurora, Ill. Two-color, 8-page catalog covers car pullers, hoists and winches, including specifications, dimensions and engineering information on how to select the proper size of mechanisms.

*Nuttall Works, Westinghouse Electrical & Mfg. Co.*, Pittsburgh, Pa. 12-page booklet, Descriptive Data 3620, illustrates and describes Types SH and DH speed reducers, with standard ratios from 2.82:1 to 70.5:1 and capacities from one to 500 horsepower.

*Leeds & Northrup Co.*, Philadelphia, Pa. New 20-page illustrated Catalog N-95-163 covers Micromax condensate purity instruments for the steam plant. Complete description of instruments and their use is given.

*Chain Belt Co.*, Milwaukee, Wis. Bulletin No. 331 is a well-illustrated 16-page booklet entitled "How To Handle It With REX Coal and Ash Handling Equipment." Many pictures of coal-handling installations and drawings of typical uses are included.

*Nuttall Works, Westinghouse Electrical & Mfg. Co.*, Pittsburgh, Pa. Westinghouse gearmotors are illustrated and described in an 8-page booklet, Descriptive Data 3620. Gearmotor ratings are available from ¾ to 75 horsepower, with three standard motor speeds and 46 standard gear ratios with each motor speed.

*The Bristol Company*, Waterbury, Conn. Bulletin No. 514 gives complete information on Synchro-Valves for use with pneumatic-type pressure flow, liquid level, temperature and humidity controllers, also three-way and four-way diaphragm valves.

*The Foxboro Company*, Foxboro, Mass. Bulletin No. 202-2 is a 24-page booklet which illustrates and describes the construction features and operation of Foxboro potentiometer controllers.

*South Bend Lathe Works*, South Bend, Ind. New Model 9-in. workshop precision lathe is announced in a 32-page catalog, No. 46-B.

*The Elwell-Parker Electric Co.*, Cleveland. A 4-page illustrated bulletin, No. A-8416, includes description and specifications of the "IZ" Load-Carrier Truck. This truck has a rigid platform, 84 in. long by 40 in. wide and 25 in. high, the load capacity being 6,000 lb.

*Link-Belt Co.*, Chicago, Ill. Book No. 1630 pictures a variety of ideas for handling materials and commodities on overhead conveyors.

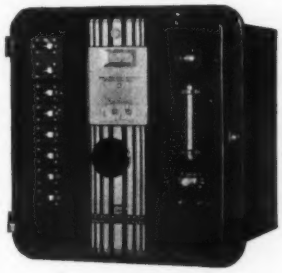
### NEW DEVELOPMENT IN BANDING WHEELS

The O. Hommel Co., Pittsburgh, reports the development of a free-running wheel on which friction has been reduced to merely a needle-point contact and states that this is the latest design in banding wheels for the modernly equipped decorating shop. By an ingenious construction of the "suspended" ball bearing, which will never wear out with normal use, this banding wheel gives a perfectly smooth-running motion. It is available in 6″, 8″, 10″ and 12″ discs also as floorstand model.

### TEMPERATURE INDICATOR

A new temperature indicator recently placed on the market by the Leeds & Northrup Co., Philadelphia, Pa., provides space for a number of toggle switches by which any one of a number of thermocouples may be connected to the measuring circuit. Installed in any convenient location, the new instrument enables an operator to measure temperatures of near or far couples with equal accuracy, the operation being completed by simply turning a knob until a pointer comes to zero and then reading the temperature on a scale.

Uncertainties due to circuit-resistance variables are eliminated by the use of a potentiometer measuring circuit which is hand-standardized, but has automatic reference-junction compensation. The scale is practically uniform



and equally accurate throughout and can be calibrated for single or double range, the latter for use with similar or different couples. Built-in terminals, check key and mercury thermometer can be included for checking with a portable indicator.

The rigid metal case can be mounted flush in a panel or may be equipped with hangers for surface mounting. The galvanometer is a replaceable unit and the only maintenance necessary is occasional dry cell replacement. Warning that a dry cell must be renewed is given when a red disc appears above the indicator scale.

## GLASS TO DOMINATE NEW ARCHITECTURE

A new architecture in which glass will be the dominating material, making possible hitherto unattainable effects of light and color, was described by Frank Sohn, designer for the Vitrolite division of the Libbey-Owens-Ford Glass Co., in one of the Metropolitan Art Museum's lecture series on "Color and Design," in New York.

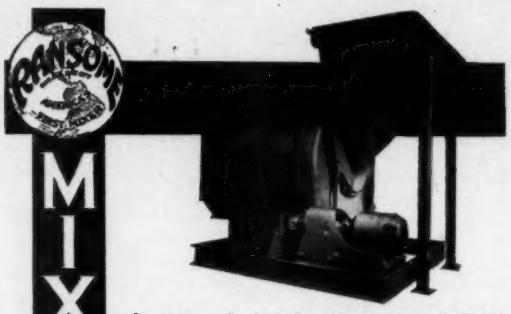
To illustrate what glass will do for both exteriors and interiors in this new architecture, Mr. Sohn displayed large glass panels imported from France and Belgium, and which had been shown at the Paris Exposition in 1937. The speaker reviewed residential architecture from the break away from "traditional" types to the latest developments in color and light and stated that, since it was found that the cubist styles of a few years ago satisfied neither the public nor the designers themselves, a refined style has grown up utilizing primarily the many new types of structural and decorative glass.

Most architecture today, Mr. Sohn said, creates the impression that the weight of the structure is borne by the walls, but in many types of buildings this is not a true "picture" and architecture which creates this impression is "esthetically dishonest." The walls of the new "glass houses" are constructed of transparent, translucent and opaque glass, hanging like curtains from the supporting frame work, and enable the architect to gain revolutionary effects in light, color and design.

A strong force in the movement toward this new architecture is the desire to achieve a true "partnership" between the home and the garden—to bring the beauty of th outdoors into the living quarters. No school of architecture, according to Mr. Sohn, has consciously established this new style of architecture, but the similarity of work of various architects has led to the conclusion that the "glass building" has become an accepted architectural form. He also traced the evolution of architecture for expositions, the Paris Exposition of 1937 having had many examples of the new trend toward glass. Recent expositions and fairs in this country have also produced several examples of the new glass architecture.

Glass now is being used, he continued, to accent the beauty of interiors, much as jewelry is used in evening gowns. Such supplementary uses as built-in illumination, glass lighting fixtures and translucent wall and ceiling panels illustrate the uses of glass in modern artificial lighting technique. Turning to mirrors, Mr. Sohn noted a new decorative trend made possible by fine, clear and tinted plate glasss mirrors for interiors, this trend being well-established in Europe and rapidly becoming popular on this side of the Atlantic. Decorators are able to design one half of a room and by ingenious use of a full-mirrored wall, or mirror-faced adjoining walls, double the apparent size of the room and multiply the beauties of the furnishings.

The lecturer displayed more than a dozen types of industrial and architectural glasses, all of American manufacture and design, including structural glass panels, glass block, moulded architectural glass, heat-resisting glass, vitrolux, tuf-flex, decorative mirrors, carved and etched glass and several imported panels. Mr. Sohn also mentioned an important development in glass design, the increased use of industrial glasses for leaded-glass windows, instead of the types of glass formerly used for this purpose.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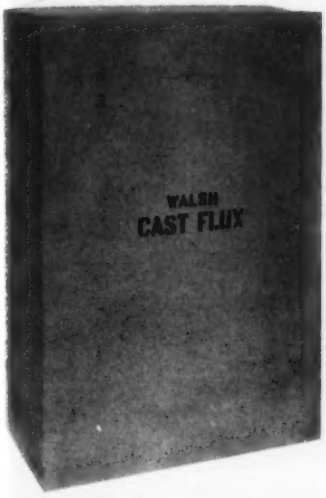


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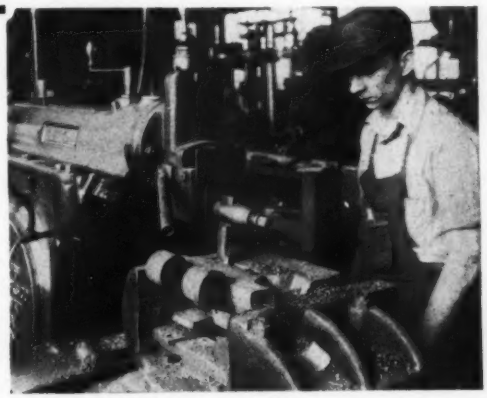

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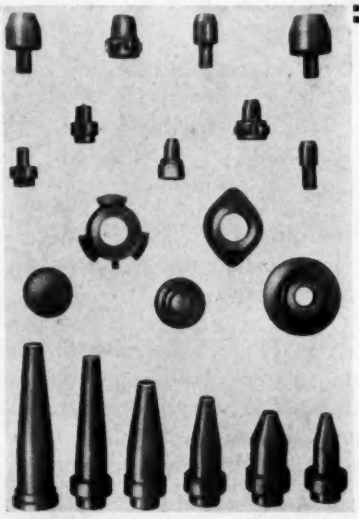

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